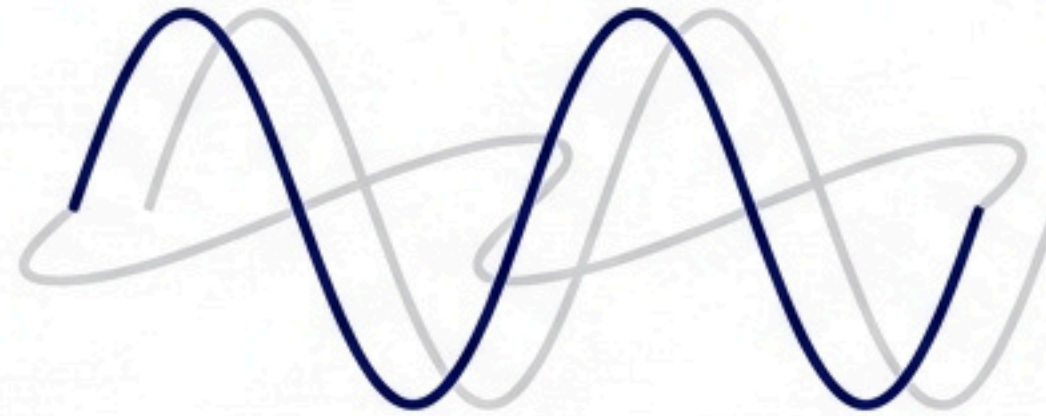




CHAPTER 8.3.1 • ELECTROMAGNETIC WAVES

Why Only Accelerating Charges Radiate

The precise source of electromagnetic radiation
and its historical validation.

THE PRINCIPLE

State of Motion vs. Electromagnetic Effect

Stationary Charge



Produces only electrostatic fields.

✗ DOES NOT RADIATE

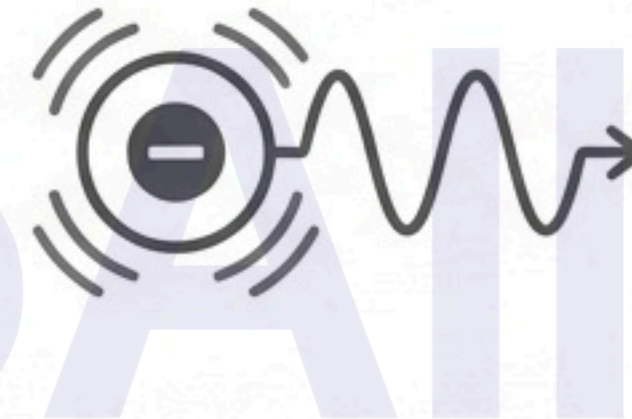
Uniformly Moving Charge



Produces magnetic fields, but they do not vary with time (steady currents).

✗ DOES NOT RADIATE

Accelerating / Oscillating Charge



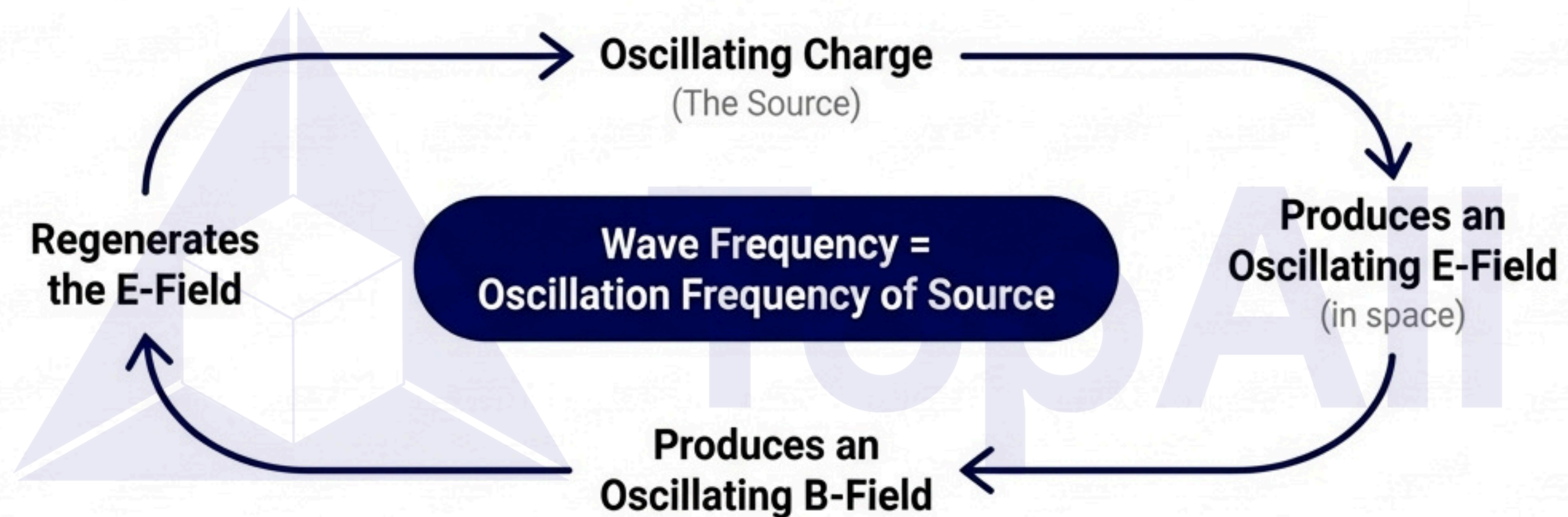
Produces time-varying electric and magnetic fields.

✓ EMITS EM WAVES

Energy for the propagating wave comes at the expense of the source (the accelerated charge).

THE MECHANISM

The Regeneration Loop



Time-varying electric and magnetic fields mutually regenerate each other, allowing the wave to propagate independently through space.



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

$$E=mc^2$$



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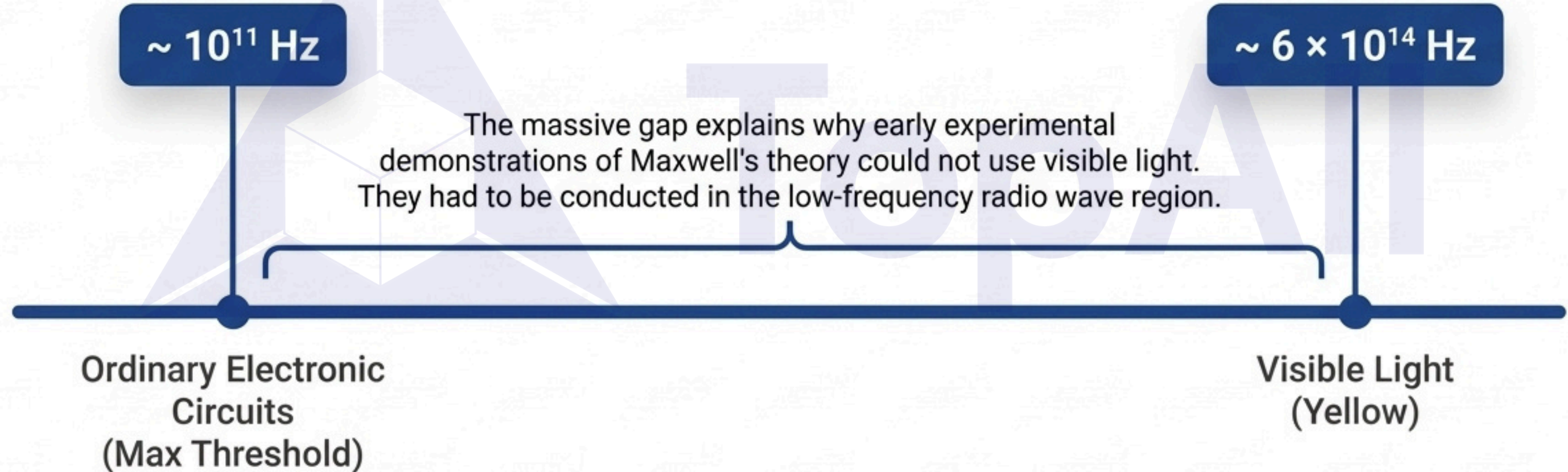
Key Highlights

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- » Push Your Limits with Level-Based Challenges
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THE LIMITATION

The Frequency Scale Problem



The First Experimental Proof



Heinrich Hertz

[1887]

[Low Frequency]

[Radio Waves]

- First to experimentally demonstrate the existence of electromagnetic waves.
- Successfully generated and detected waves in the laboratory, confirming Maxwell's theoretical predictions.

Expanding the Boundaries

**Jagdish
Chandra Bose**

Calcutta

[Shorter Wavelengths]

Succeeded in producing and observing electromagnetic waves of much shorter wavelengths (25 mm to 5 mm).
Experiment remained confined to the laboratory.

**Guglielmo
Marconi**

Italy

[Long-Distance]

Followed Hertz's work to successfully transmit EM waves over many kilometers. Sparked the communication revolution.

Key Takeaways for the Exam

Master these core concepts:

- **The Source:** Only an accelerated or oscillating charge emits EM waves. Stationary and uniformly moving charges do not radiate.
- **The Frequency:** The wave frequency strictly equals the oscillation frequency of the source.
- **The Scale:** Visible light requires frequencies ($\sim 6 \times 10^{14}$ Hz) vastly higher than ordinary electronic circuits can produce ($\sim 10^{11}$ Hz).
- **The History:** Hertz provided initial confirmation (radio waves); Bose produced shorter mm waves; Marconi achieved long-distance transmission.



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