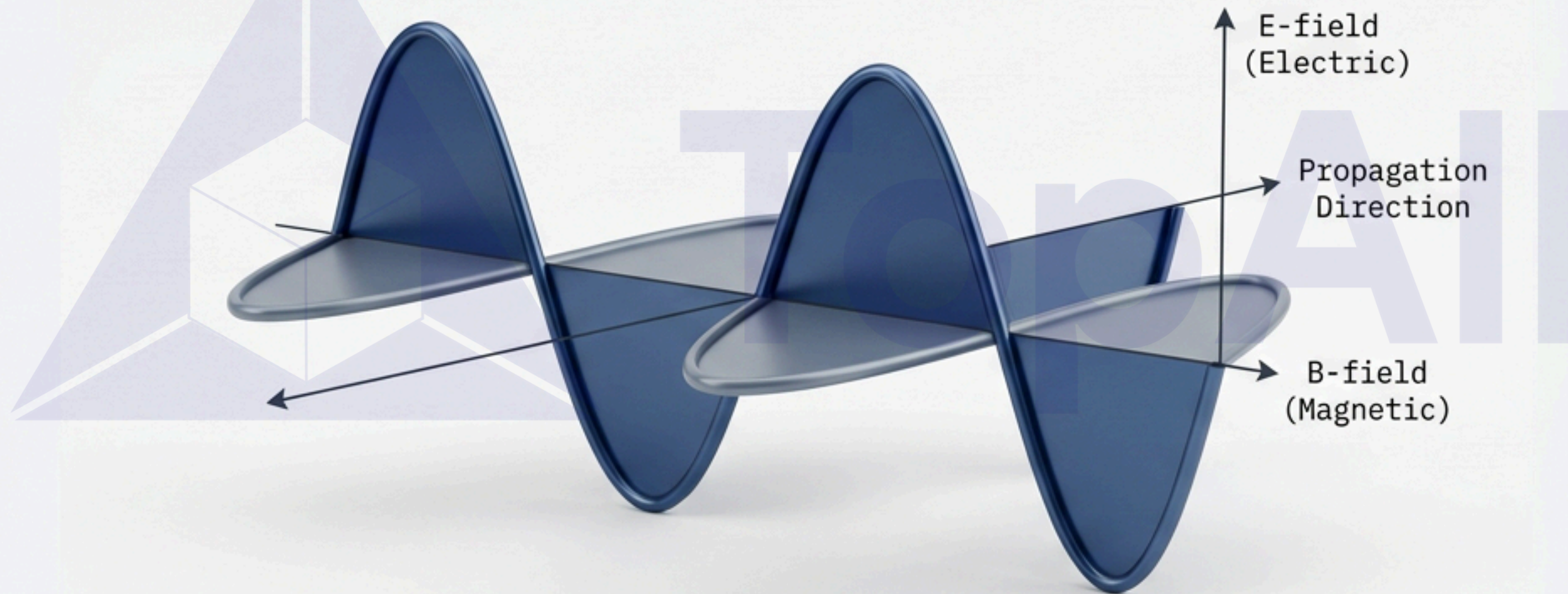


Wave Nature of Electromagnetic Radiation

From Maxwell's fields to the electromagnetic spectrum and the mathematical relationship that binds them.



Maxwell's Breakthrough: Moving Charges Create Waves

The Catalyst

Electrically charged particles move under acceleration.



The Effect

Alternating electrical and magnetic fields are produced and transmitted.



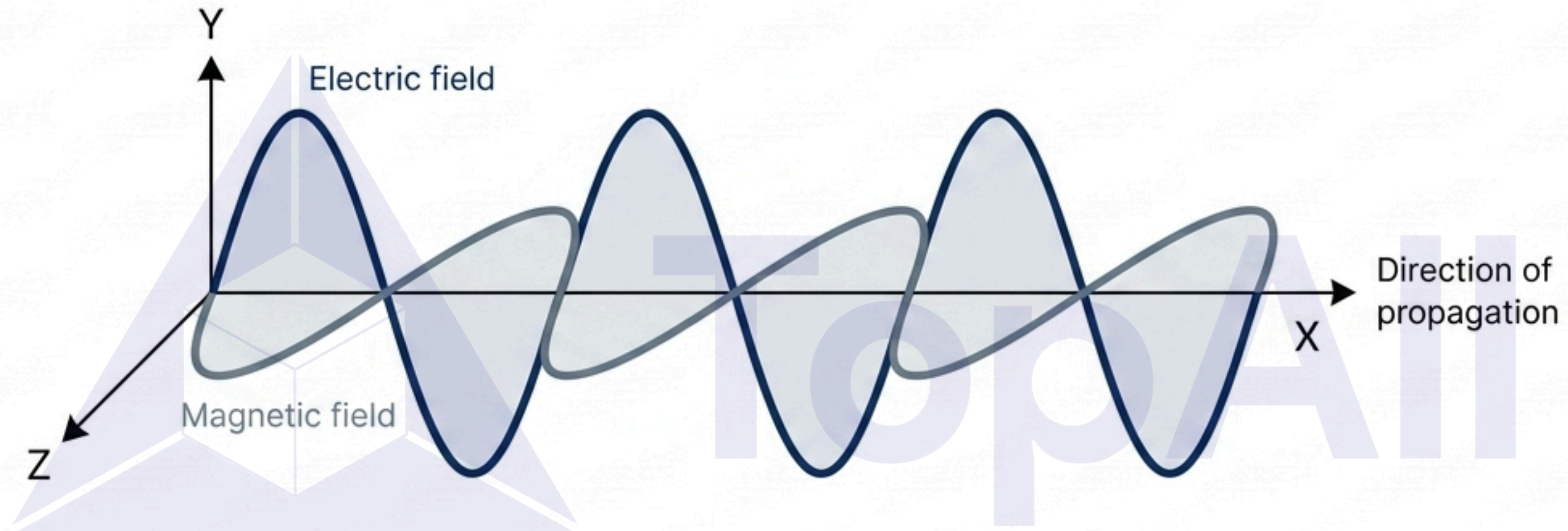
The Result

These fields propagate through space as electromagnetic waves (radiation).

The Vacuum Advantage:

Unlike sound waves or water waves, electromagnetic waves do not require a physical medium. They travel perfectly through a vacuum.

Two Mutually Perpendicular Fields



Shared Properties

Both components share the exact same wavelength, frequency, speed, and amplitude.

Spatial Relationship

They vibrate in mutually perpendicular planes—both to each other, and to the direction the wave is moving.



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$$E=mc^2$$



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Measuring the Wave: ν and λ

Frequency (ν)

Definition:

Number of waves that pass a given point in one second.

SI Unit:

Hertz (Hz, s^{-1})

Wavelength (λ)

Definition:

The physical distance between consecutive wave peaks.

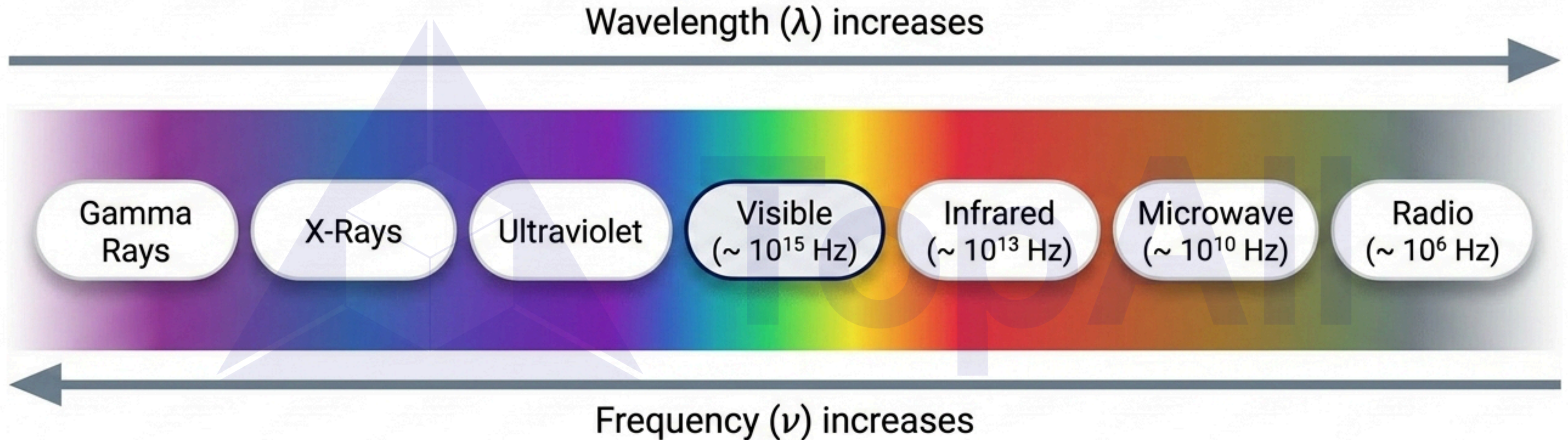
SI Unit:

Meters (m) — often expressed in nm or pm for smaller waves.

The Constant Speed: In a vacuum, all EM waves travel at the exact same speed, regardless of wavelength.

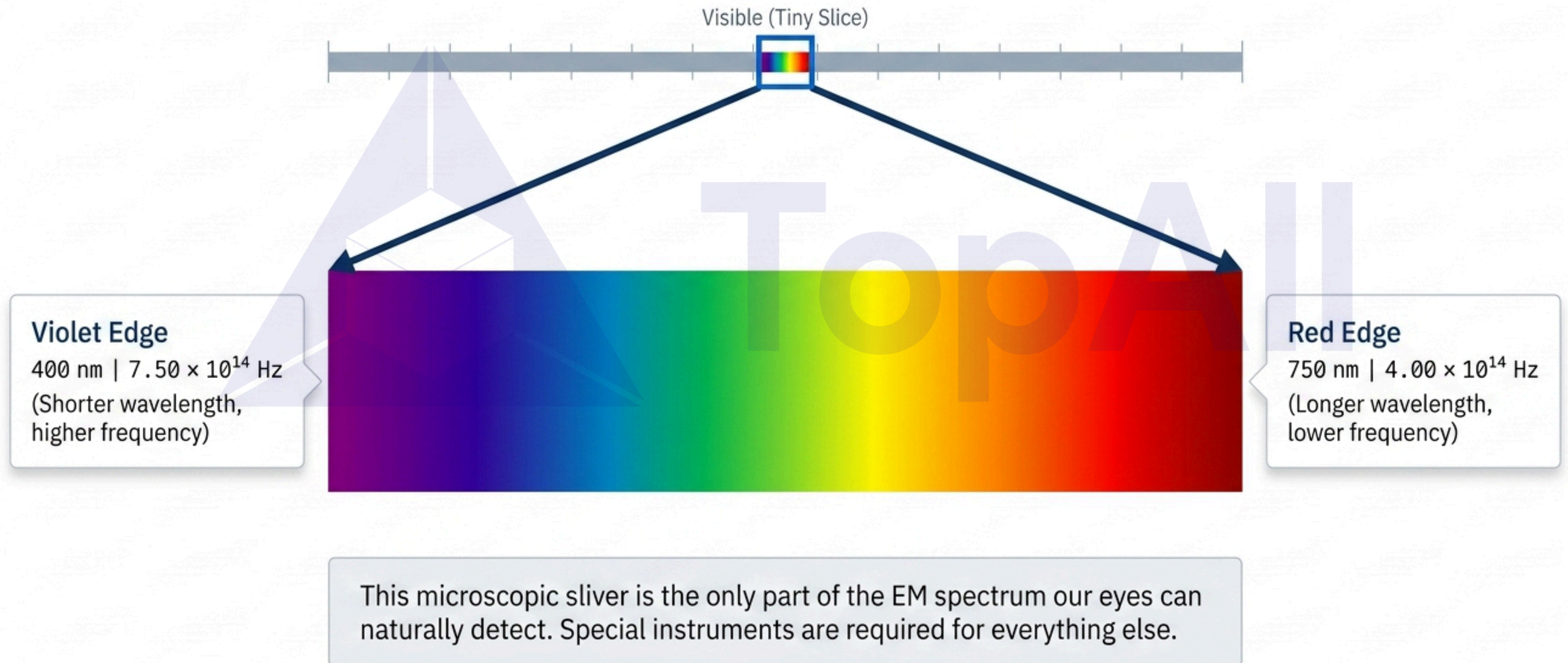
$$c = 3.0 \times 10^8 \text{ m s}^{-1}$$

The Electromagnetic Spectrum



Note: The spectrum is continuous; the distinct names are just human classifications based on how we detect or use the waves.

The Visible Region: A Tiny Slice



The Universal Equation

$$c = \nu \lambda$$

Because c is a constant (3.0×10^8 m/s), ν and λ share a strict inverse relationship.

If Wavelength (λ) is HIGH → ↑

Frequency (ν) must be LOW. ↓

If Wavelength (λ) is LOW → ↓

Frequency (ν) must be HIGH. ↑

Fields are Perpendicular

No Medium Required

Travels at 3.0×10^8 m/s

Continuous Spectrum



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