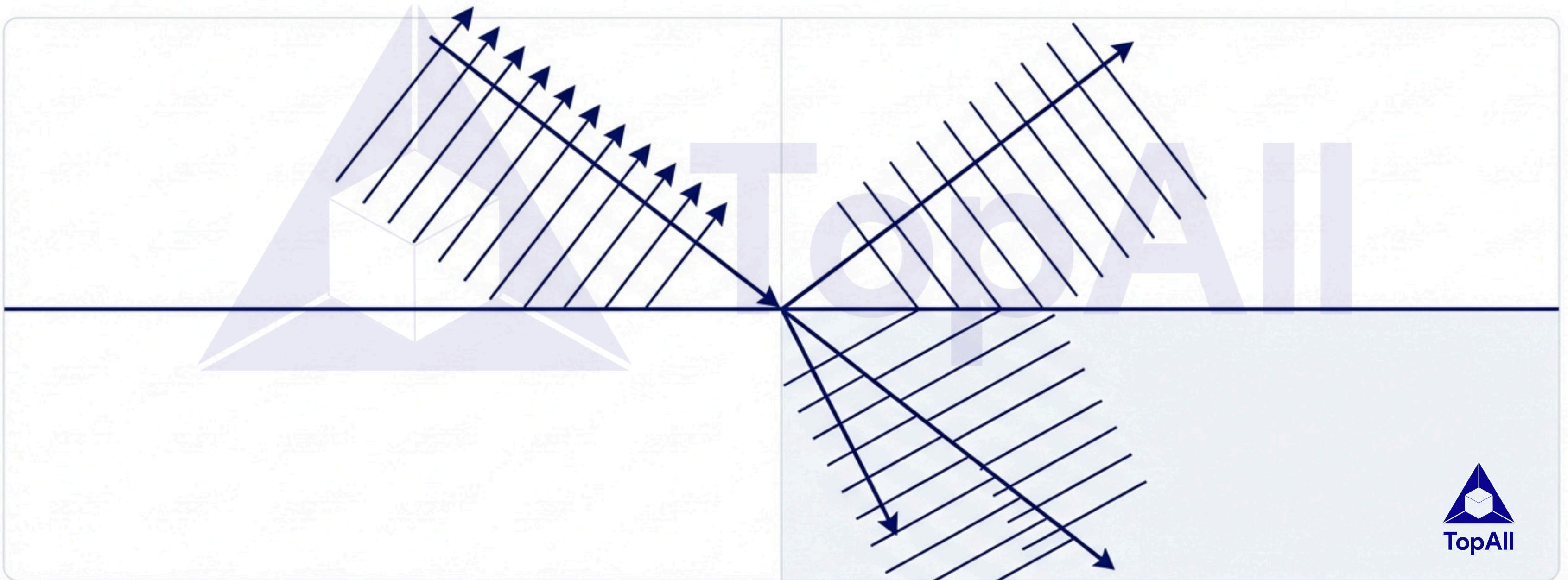


Refraction and Reflection of Plane Waves

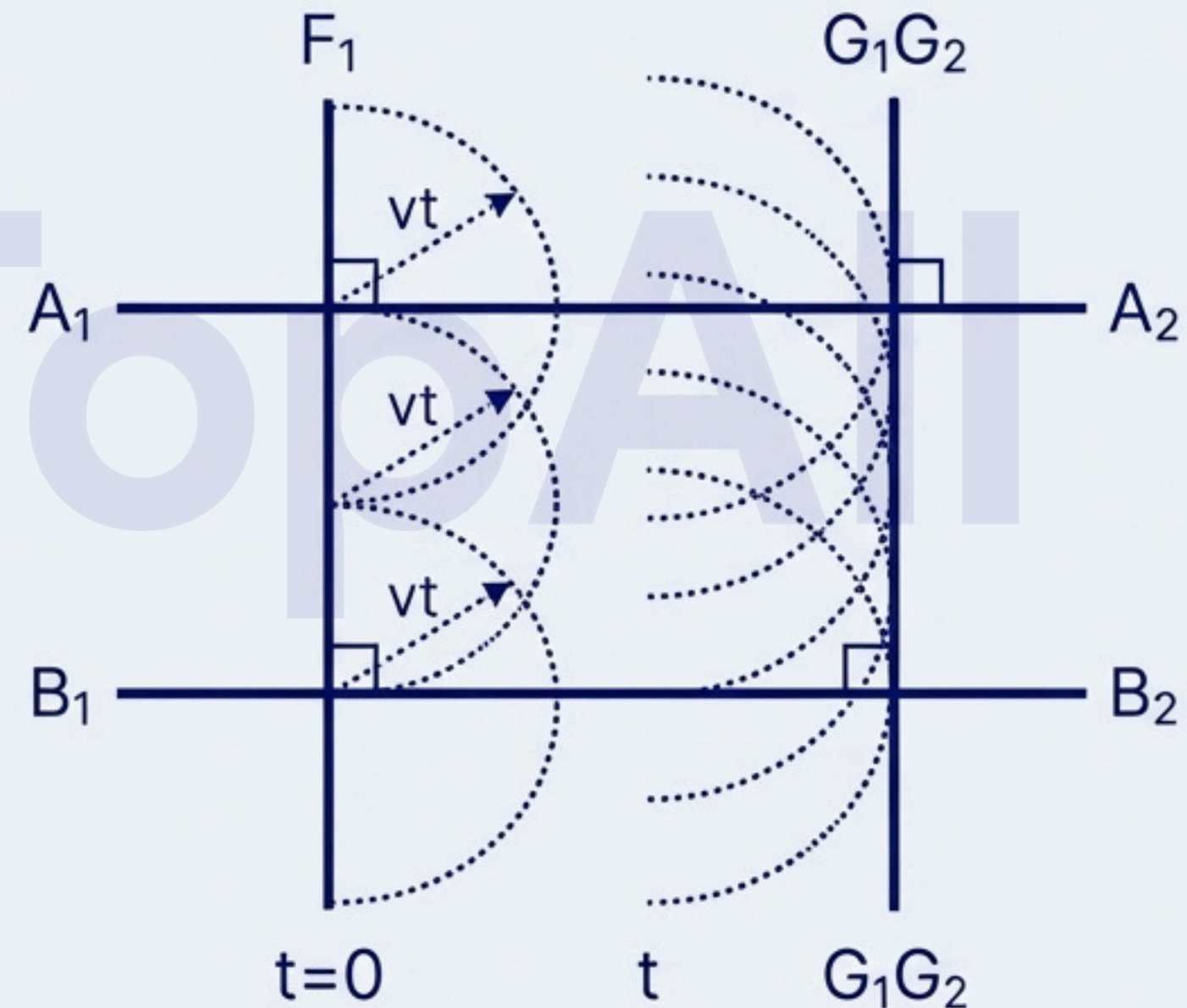
Using Huygens principle to derive macroscopic optical laws



The Baseline: Plane Wave Through a Medium

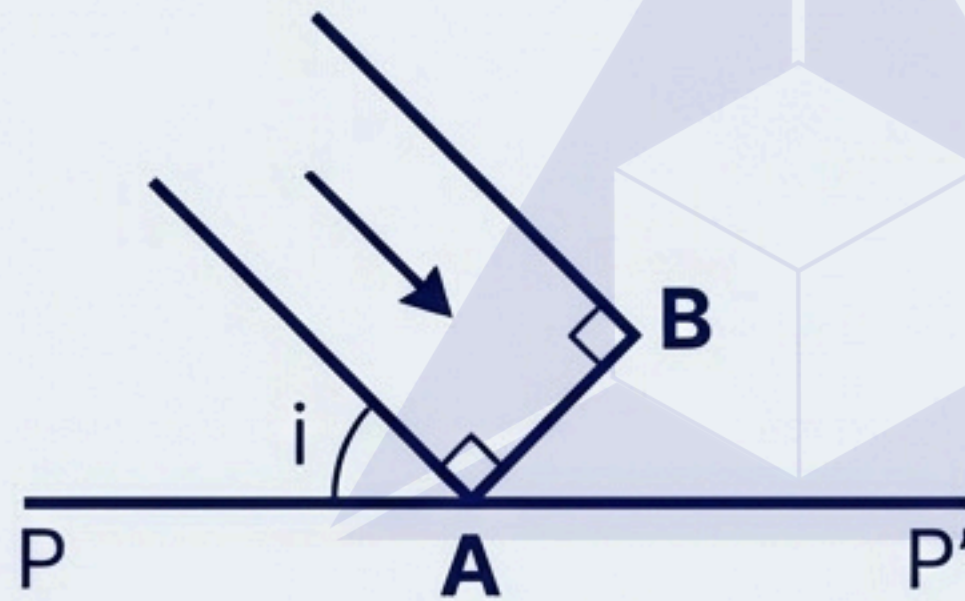
Huygens' Geometric Engine

Every point on a wavefront acts as a source of secondary spherical wavelets. These wavelets spread out in all directions with the speed of the wave (v).



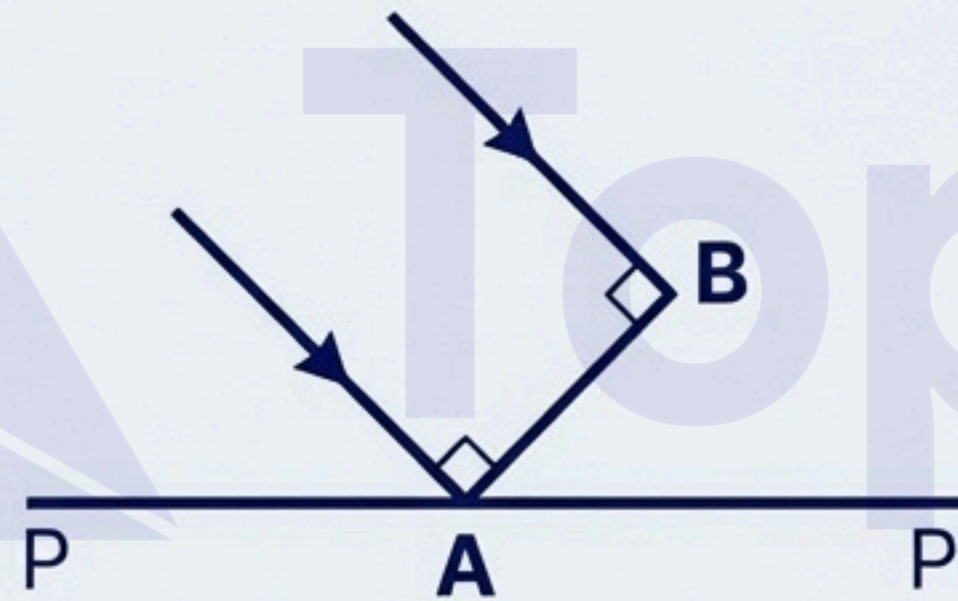
The Asymmetric Impact: Why Boundaries Matter

Time 1: Approach



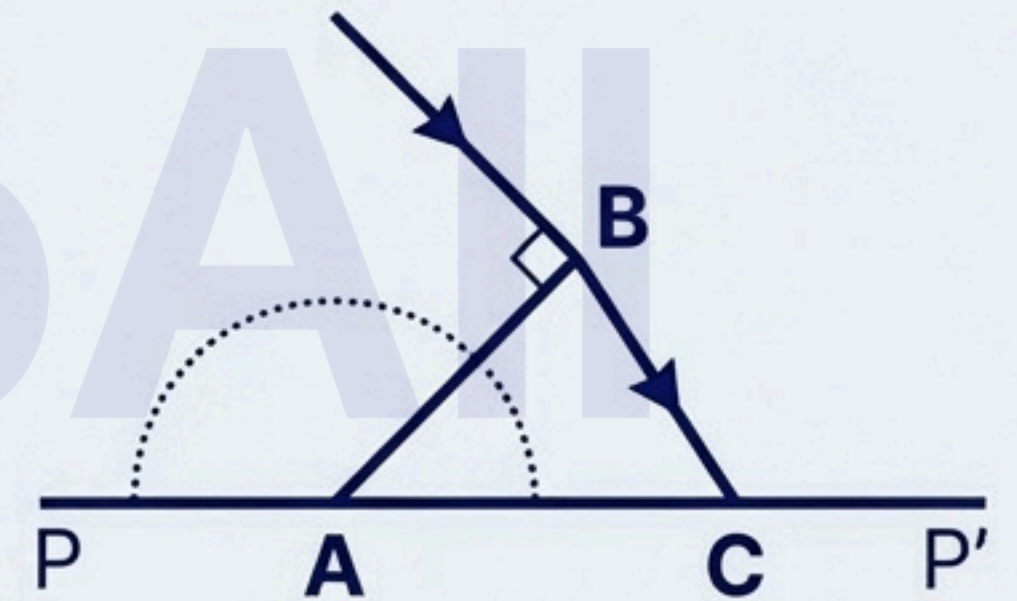
Wavefront approaches at angle i .

Time 2: Impact



Point A becomes a secondary source in a new environment, while Point B continues in the old.

Time 3: Re-formation

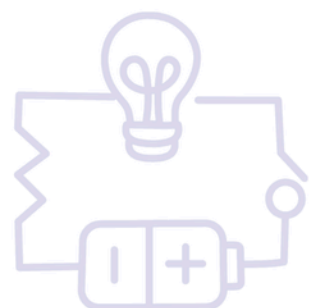
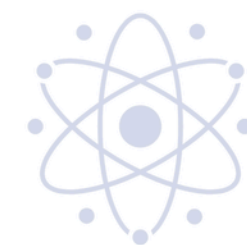


The wavefront must geometrically re-form connecting C to A's expanded wavelet.



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$$E=mc^2$$



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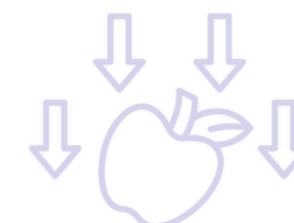
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Key Highlights

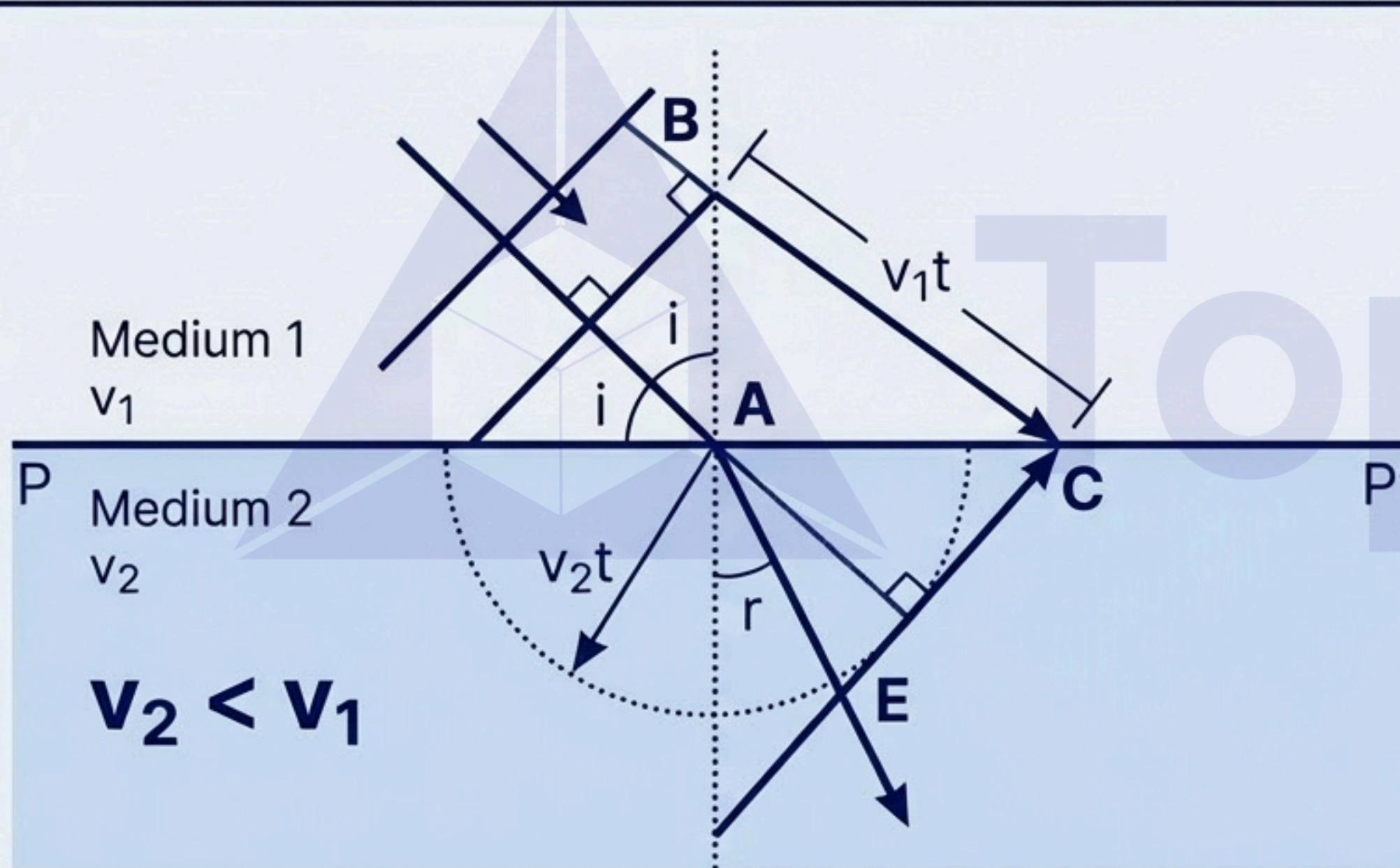


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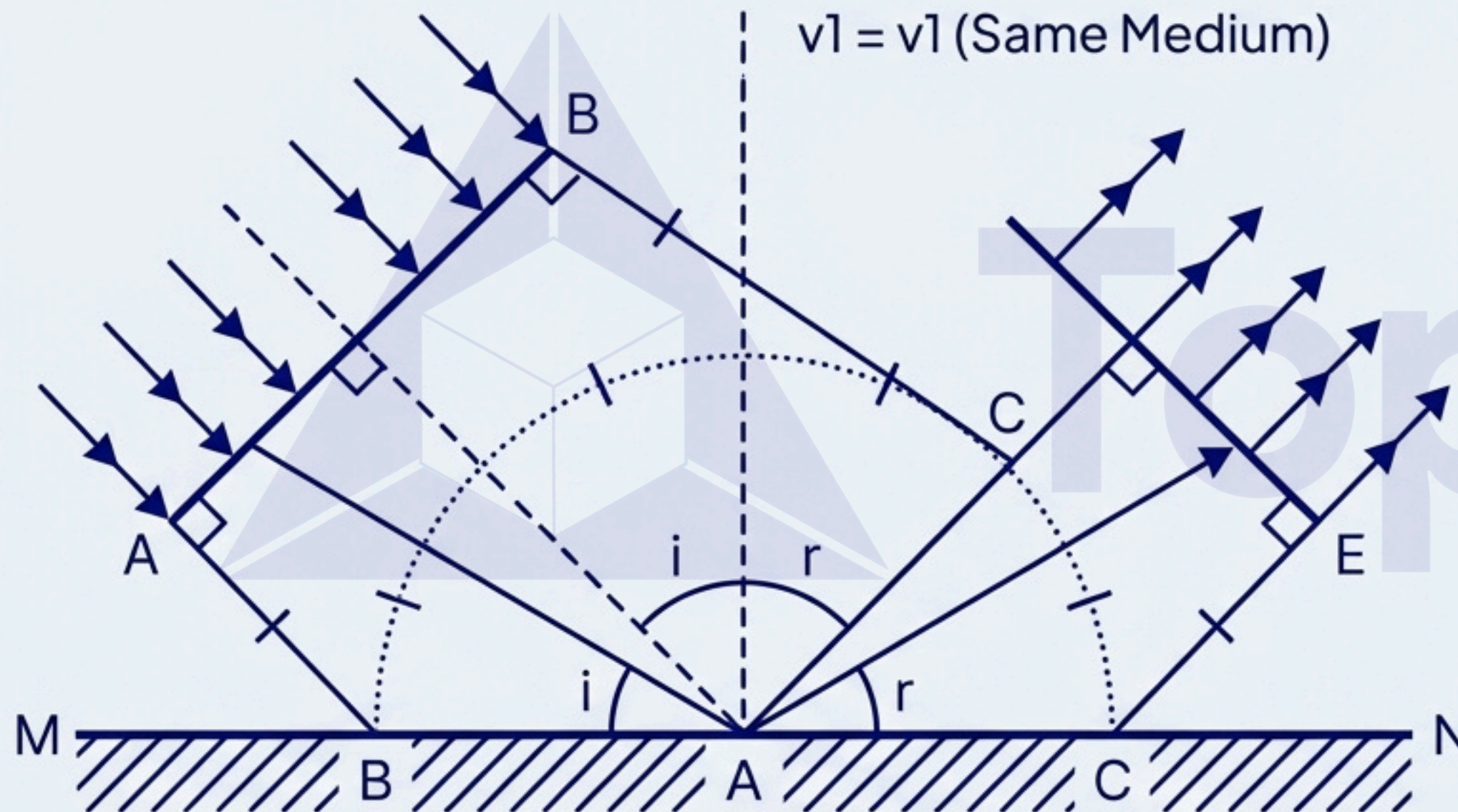
Outcome A: The Drag of a Denser Medium

Slower Speed = Inward Pivot

Because the light travels slower in Medium 2, Point A's wavelet doesn't travel as far as Point B. The geometric envelope connects these asymmetric distances, forcing the wavefront to bend towards the normal ($r < i$).



Outcome B: The Symmetry of the Same Medium



Equal Speed = Equal Angles

Because the wave bounces back into the same medium, the wavelet radius AE exactly equals distance BC. This forces triangles EAC and BAC to be perfectly congruent, proving geometrically that the angle of incidence equals the angle of reflection ($i = r$).

Synthesis: One Principle, Two Laws

	Refraction	Reflection
The Medium Condition	Wave enters a new medium.	Wave remains in the original medium.
Wave Speed Reality	Speed changes ($v_2 \neq v_1$).	Speed is identical ($v_1 = v_1$).
Wavelet Geometry	Radius AE is unequal to distance BC.	Radius AE equals distance BC.
The Macroscopic Result	Asymmetric triangles force a bent wavefront.	Congruent triangles force a symmetrical wavefront.

Huygens' construction proves that optical laws are not arbitrary formulas, but the inevitable geometric consequences of a wavefront interacting with a boundary.



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