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*Electromagnetics Vol. 2*

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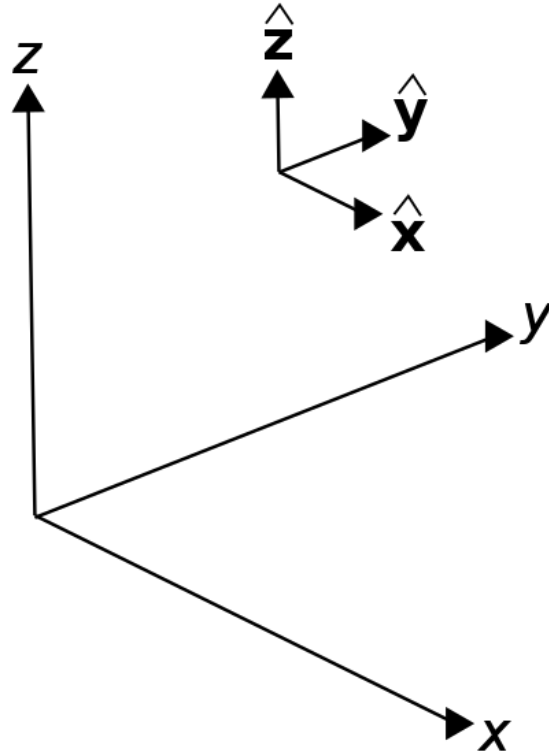


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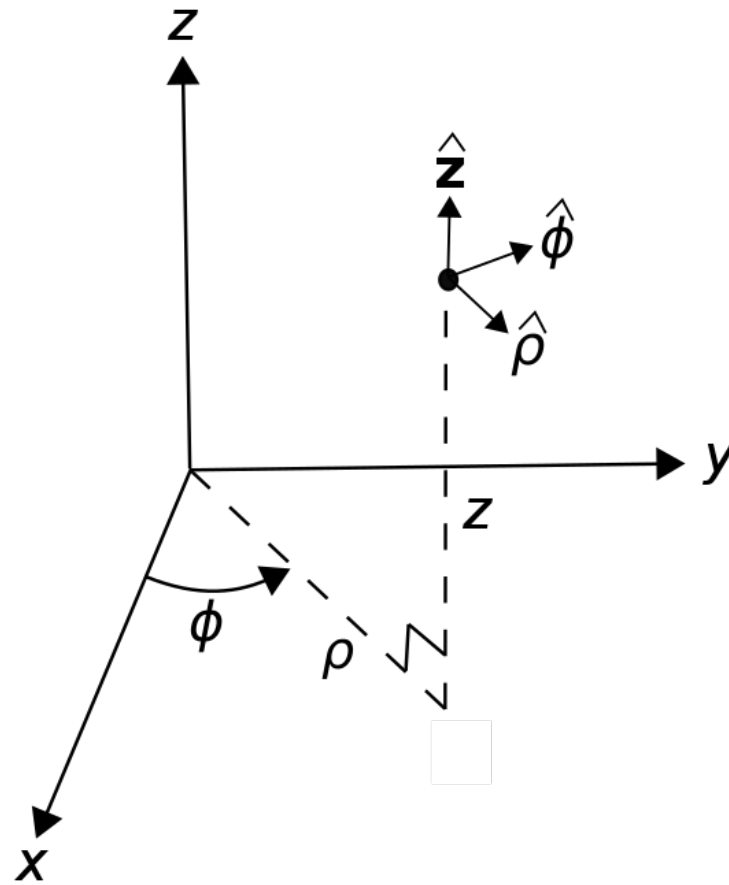


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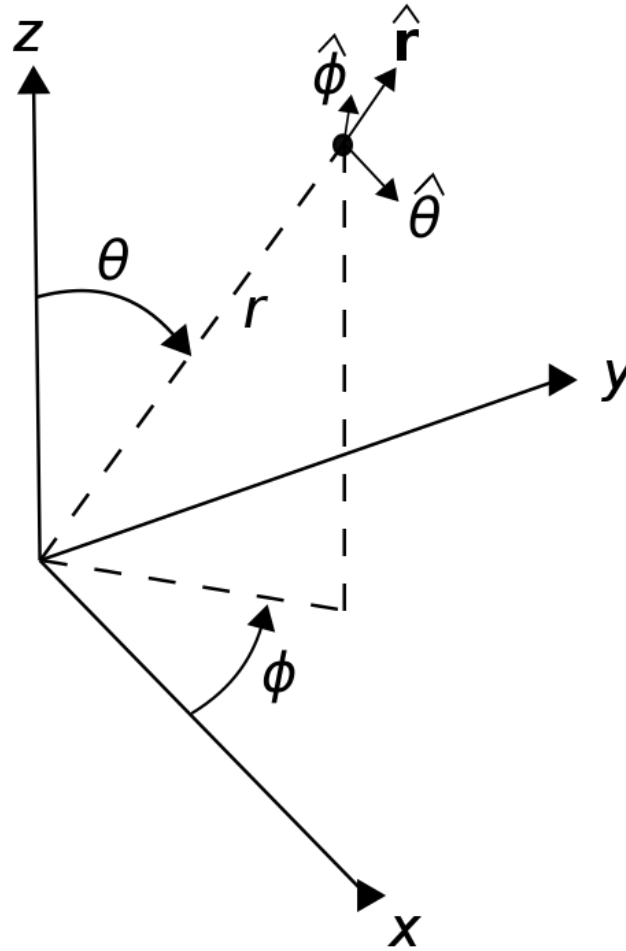


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	<b>Electrostatics / Magnetostatics</b>	<b>Time-Varying (Dynamic)</b>
Electric & magnetic fields are...	independent	possibly coupled
Maxwell's eqns. (integral)	$\oint_{\mathcal{S}} \mathbf{D} \cdot d\mathbf{s} = Q_{encl}$ $\oint_{\mathcal{C}} \mathbf{E} \cdot d\mathbf{l} = 0$ $\oint_{\mathcal{S}} \mathbf{B} \cdot d\mathbf{s} = 0$ $\oint_{\mathcal{C}} \mathbf{H} \cdot d\mathbf{l} = I_{encl}$	$\oint_{\mathcal{S}} \mathbf{D} \cdot d\mathbf{s} = Q_{encl}$ $\oint_{\mathcal{C}} \mathbf{E} \cdot d\mathbf{l} = -\frac{\partial}{\partial t} \int_{\mathcal{S}} \mathbf{B} \cdot d\mathbf{s}$ $\oint_{\mathcal{S}} \mathbf{B} \cdot d\mathbf{s} = 0$ $\oint_{\mathcal{C}} \mathbf{H} \cdot d\mathbf{l} = I_{encl} + \int_{\mathcal{S}} \frac{\partial}{\partial t} \mathbf{D} \cdot d\mathbf{s}$
Maxwell's eqns. (differential)	$\nabla \cdot \mathbf{D} = \rho_v$ $\nabla \times \mathbf{E} = 0$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{H} = \mathbf{J}$	$\nabla \cdot \mathbf{D} = \rho_v$ $\nabla \times \mathbf{E} = -\frac{\partial}{\partial t} \mathbf{B}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial}{\partial t} \mathbf{D}$

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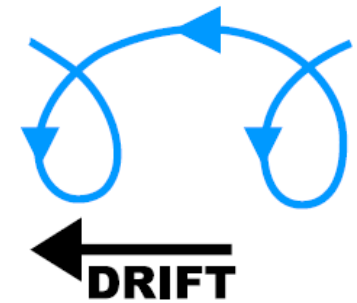
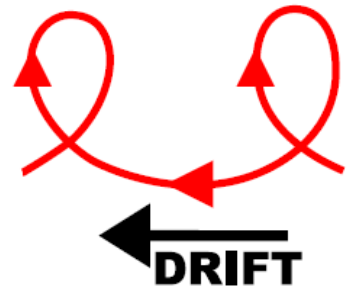
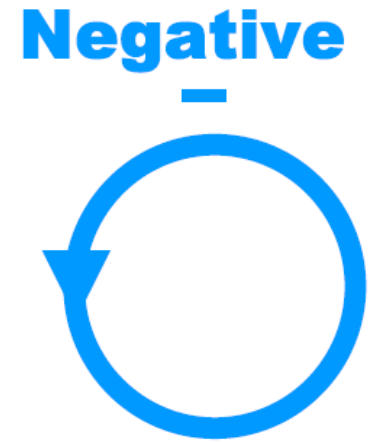
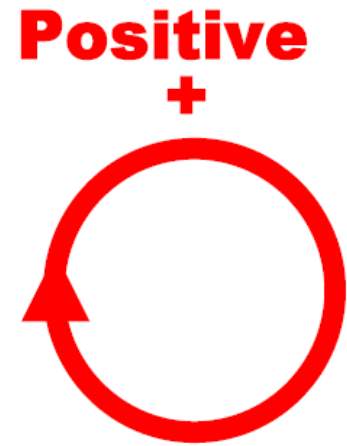


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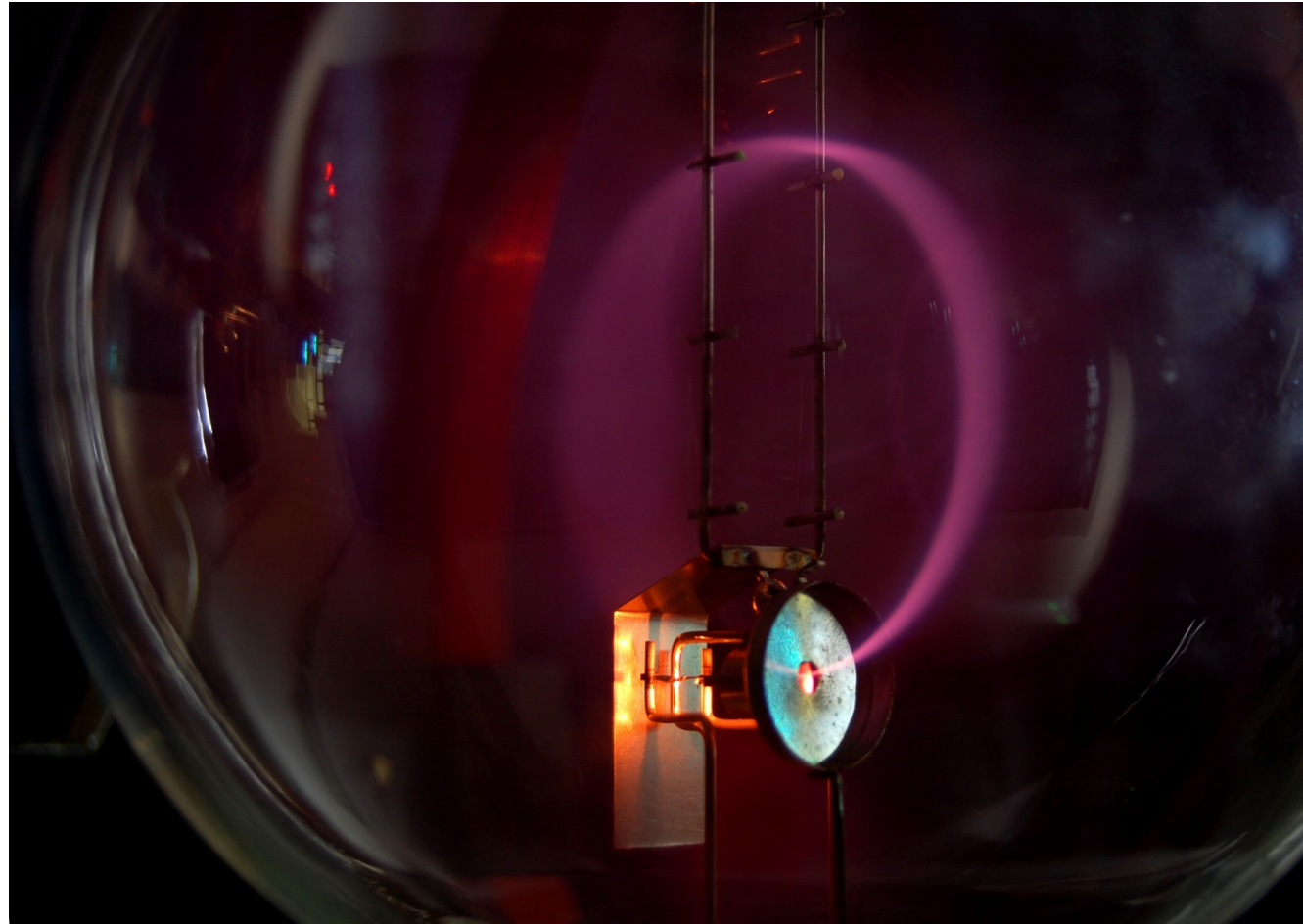


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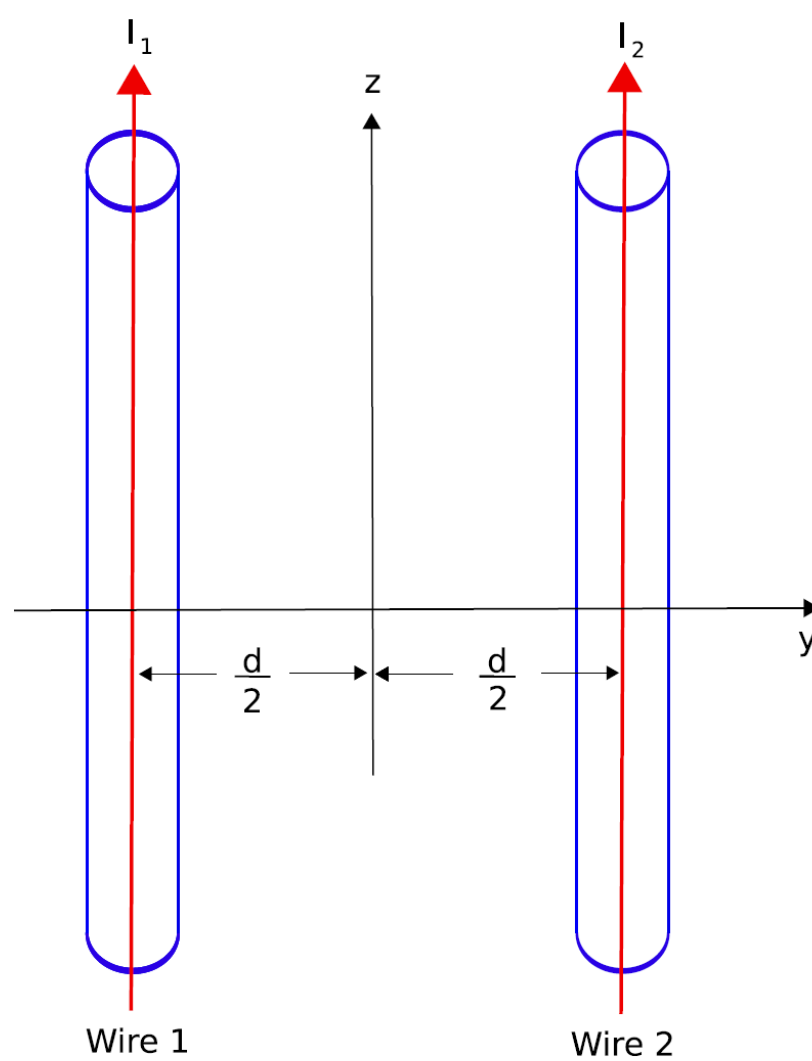


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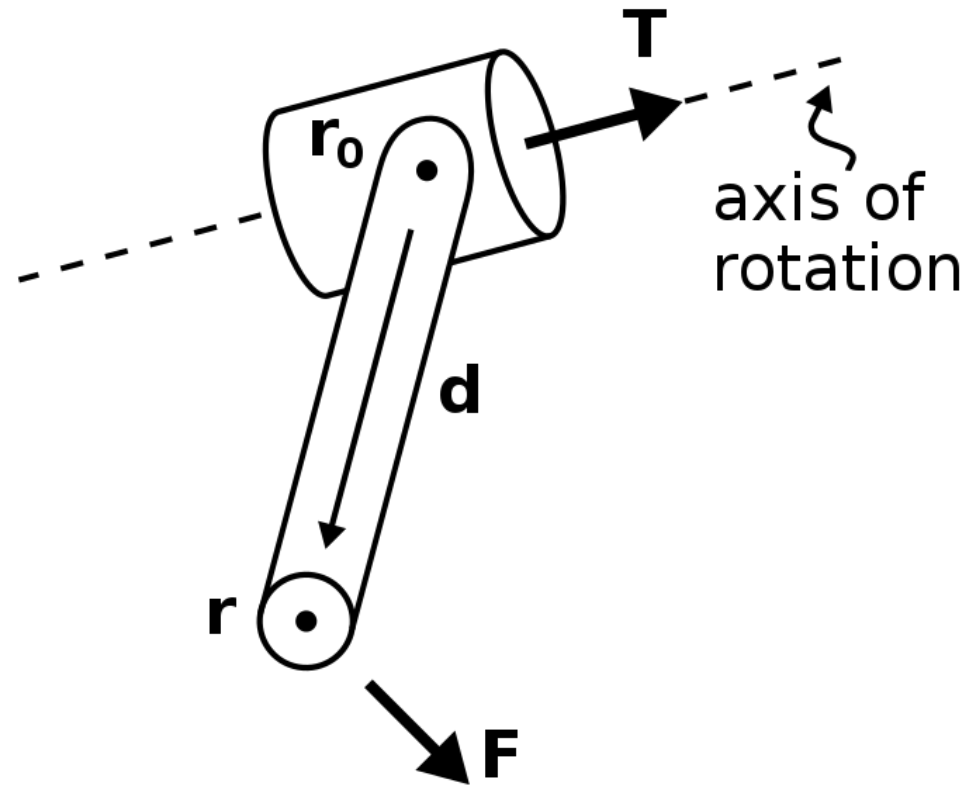


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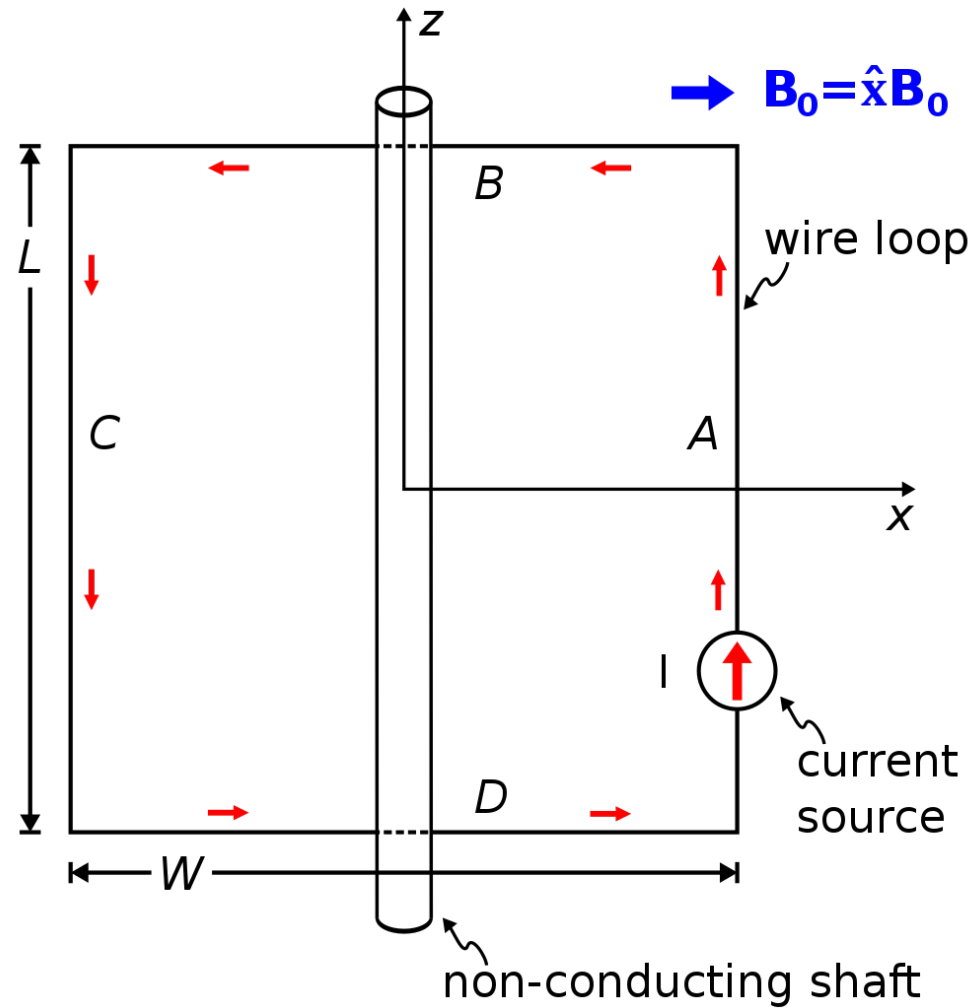


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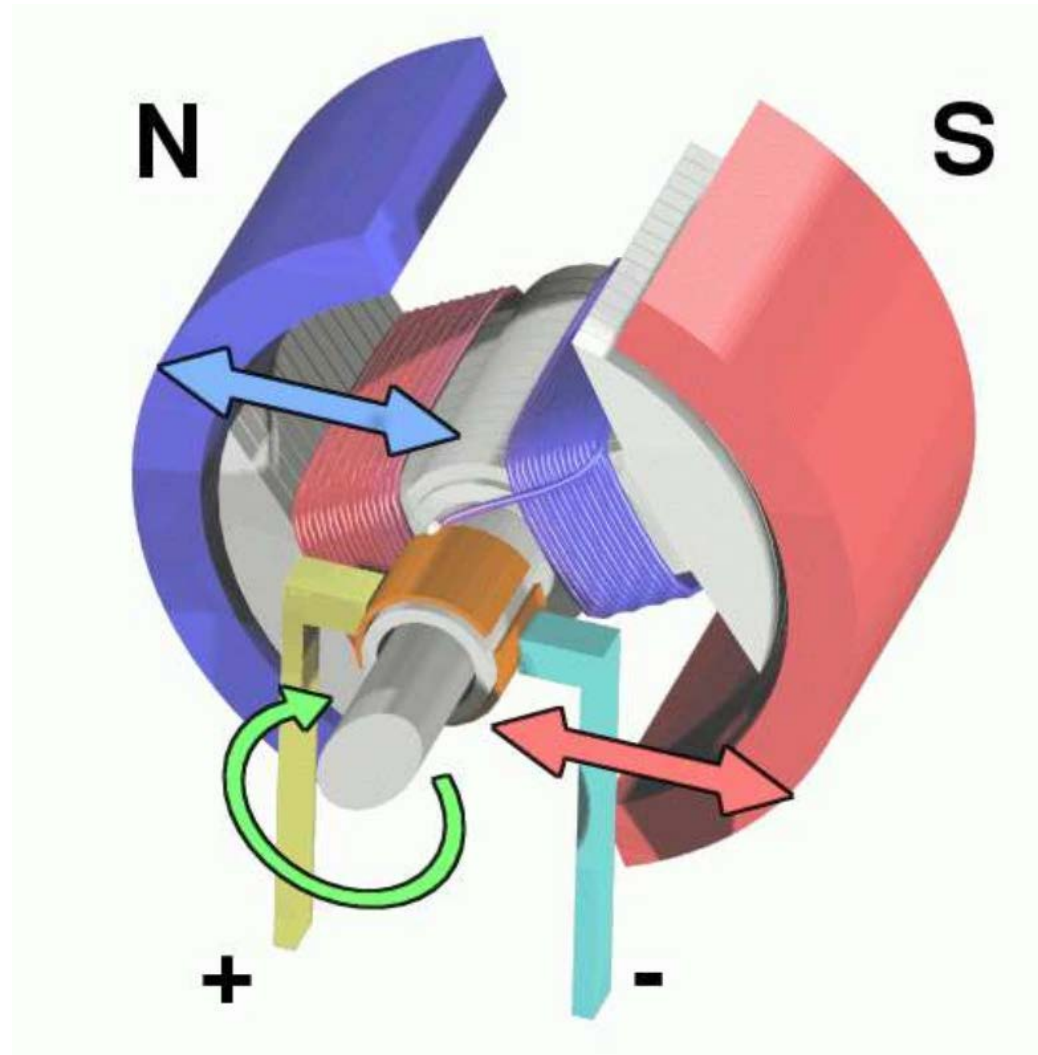


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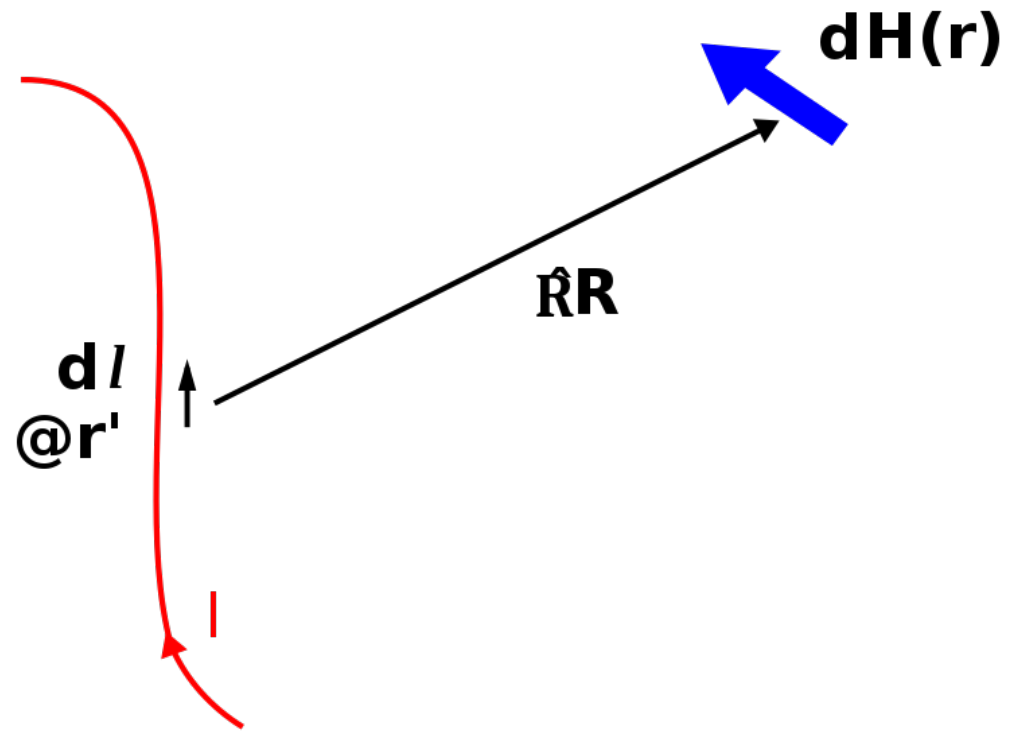


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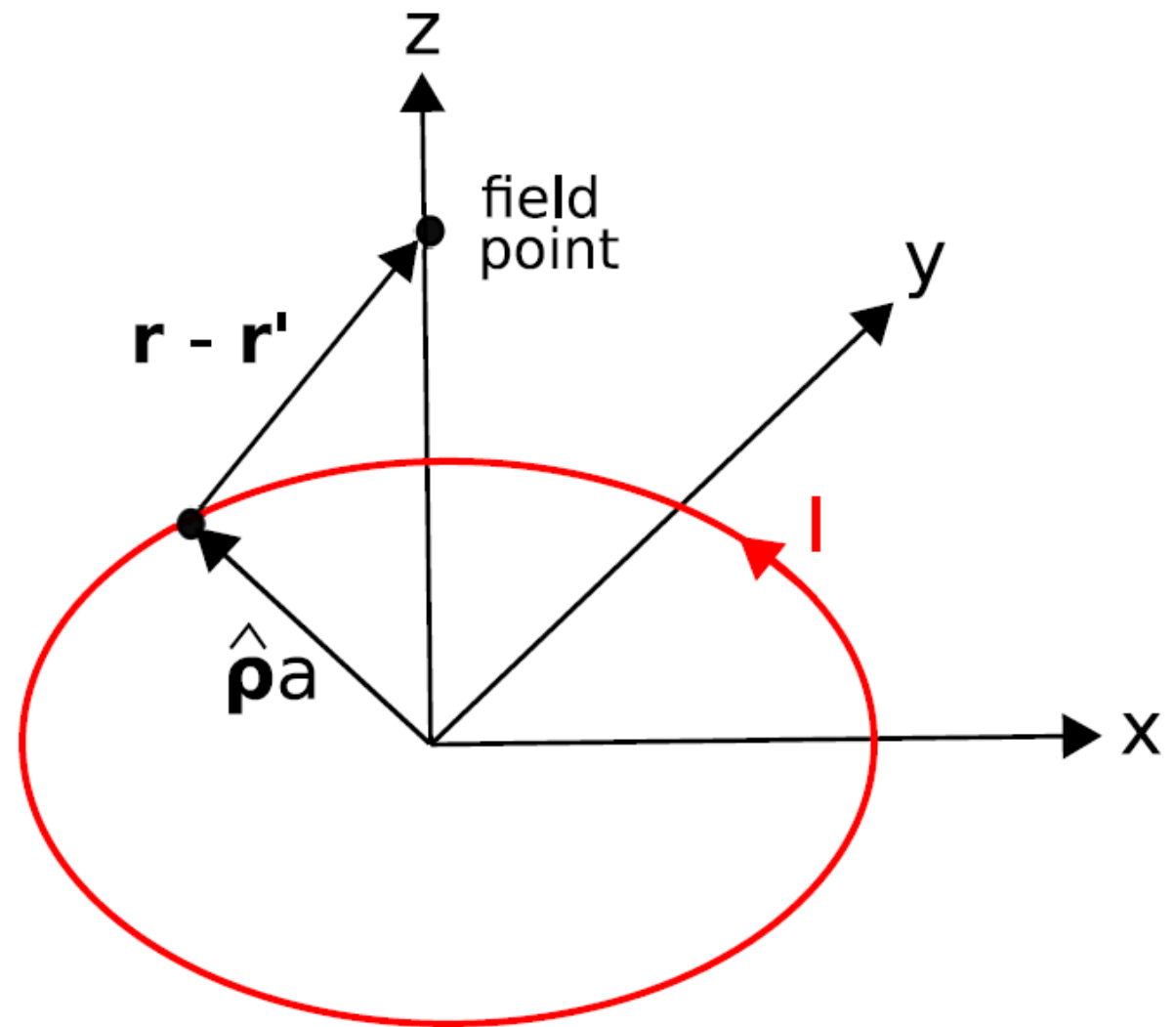


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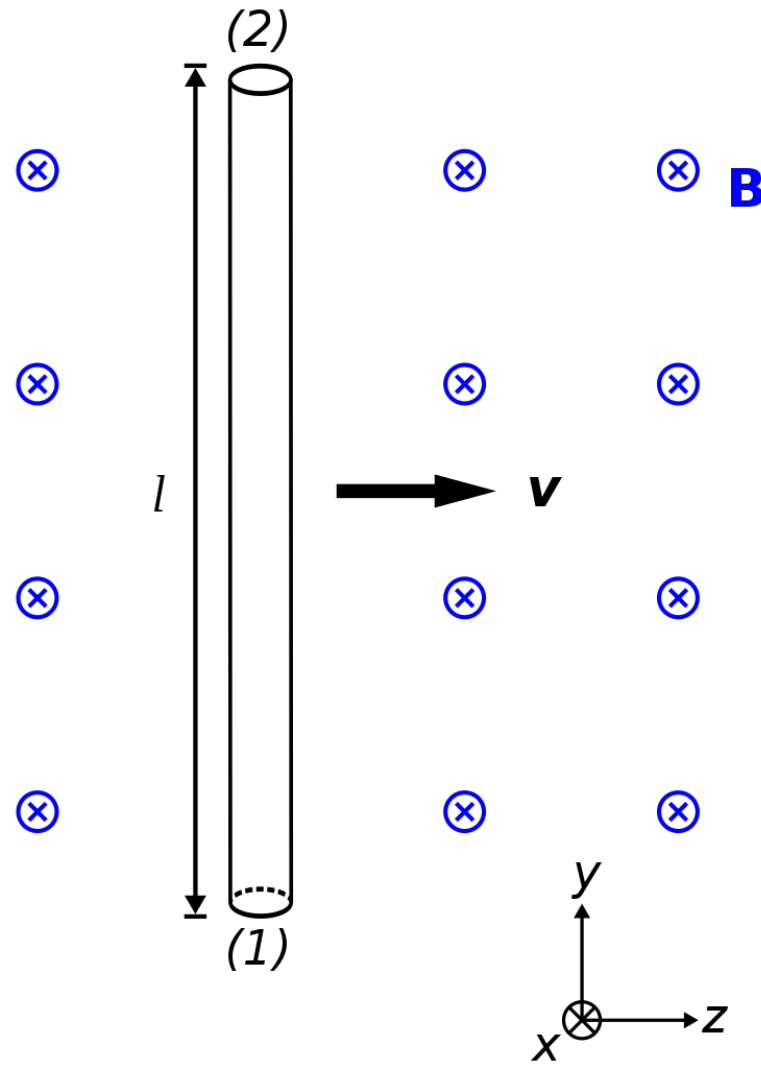


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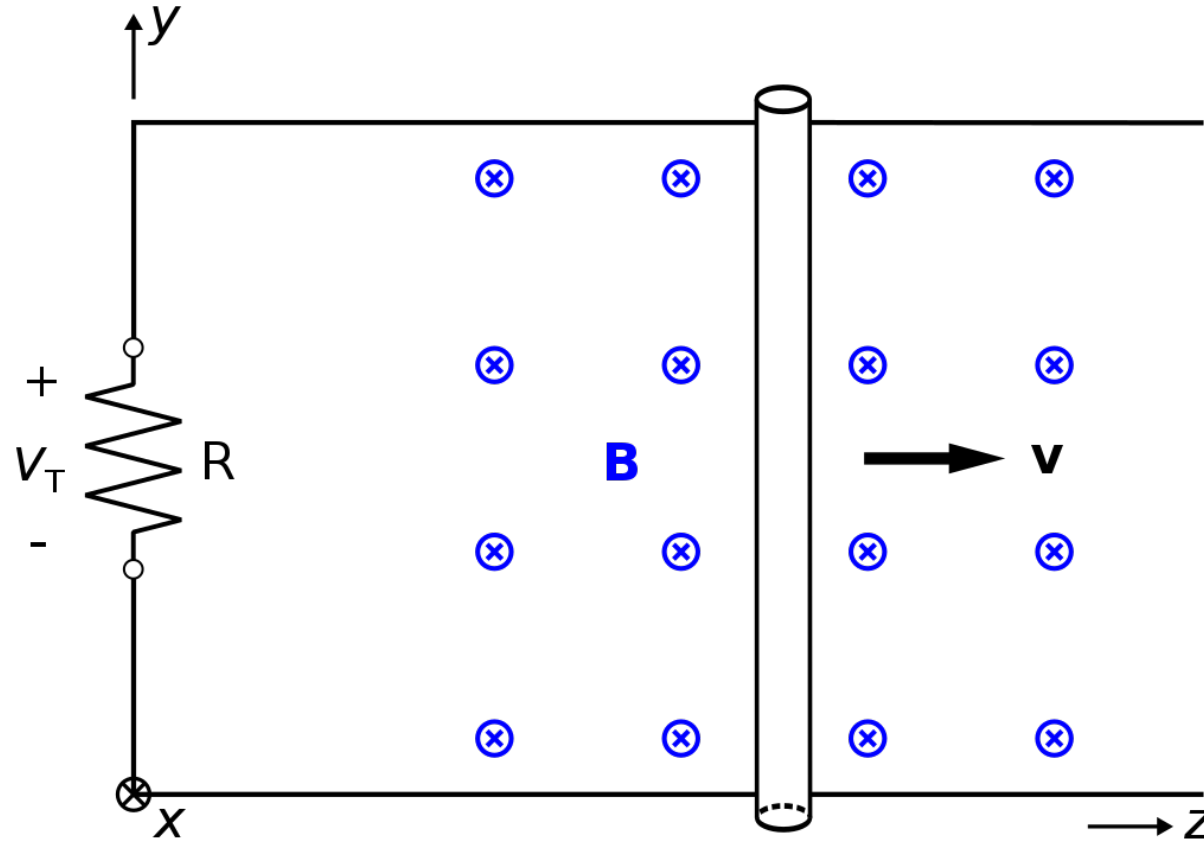


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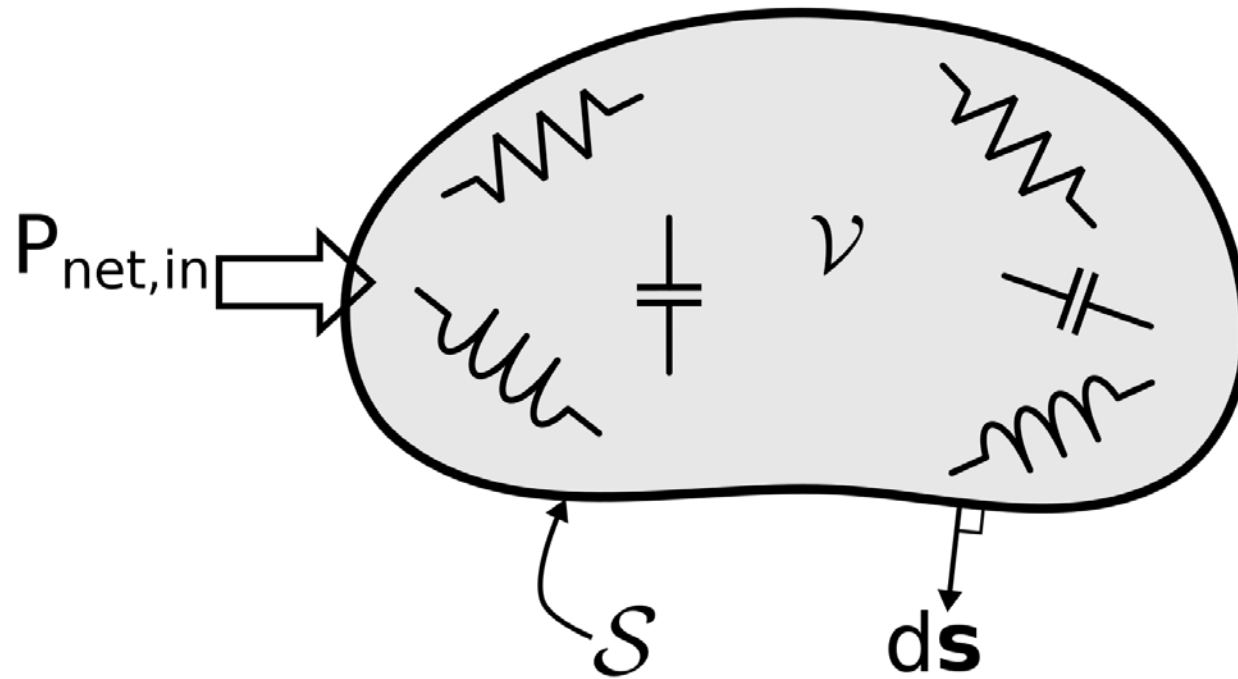


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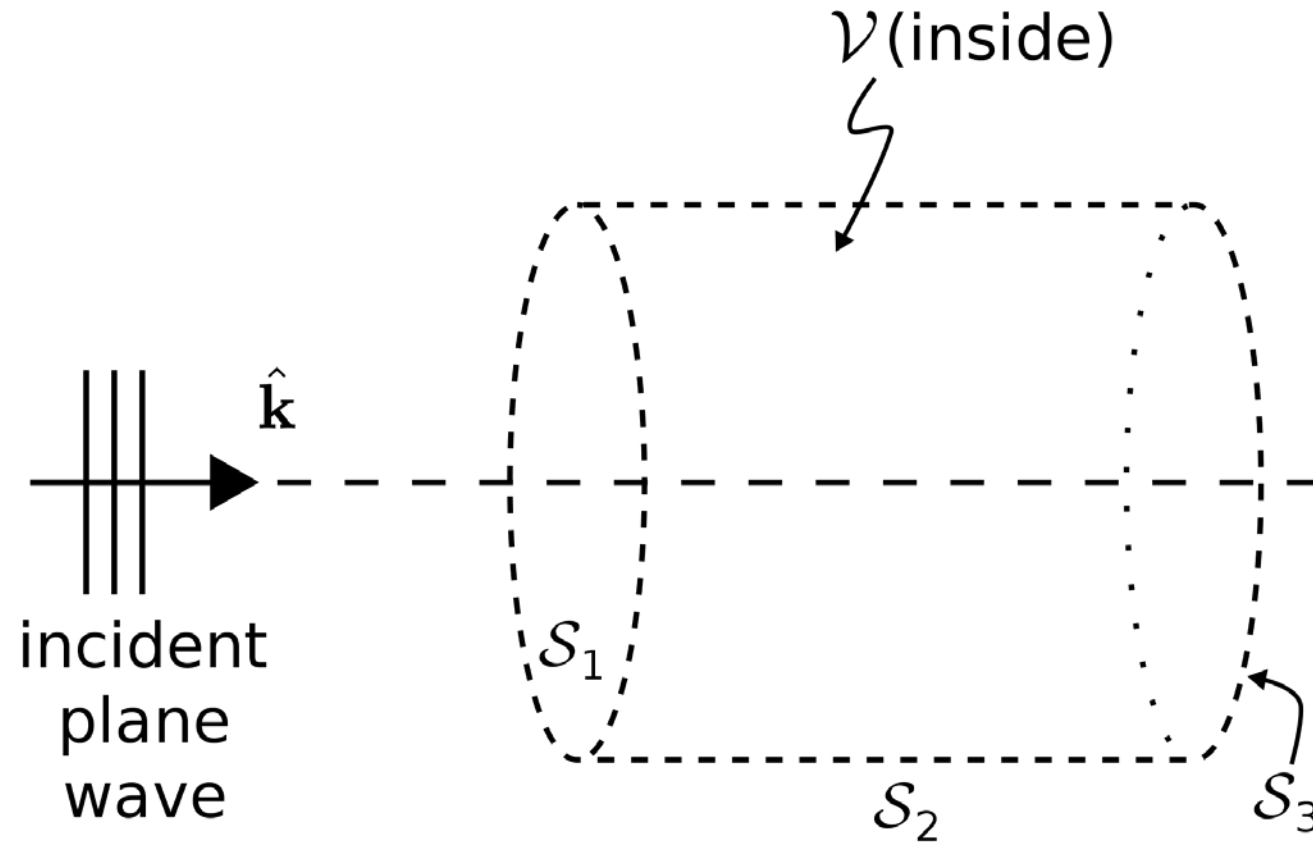


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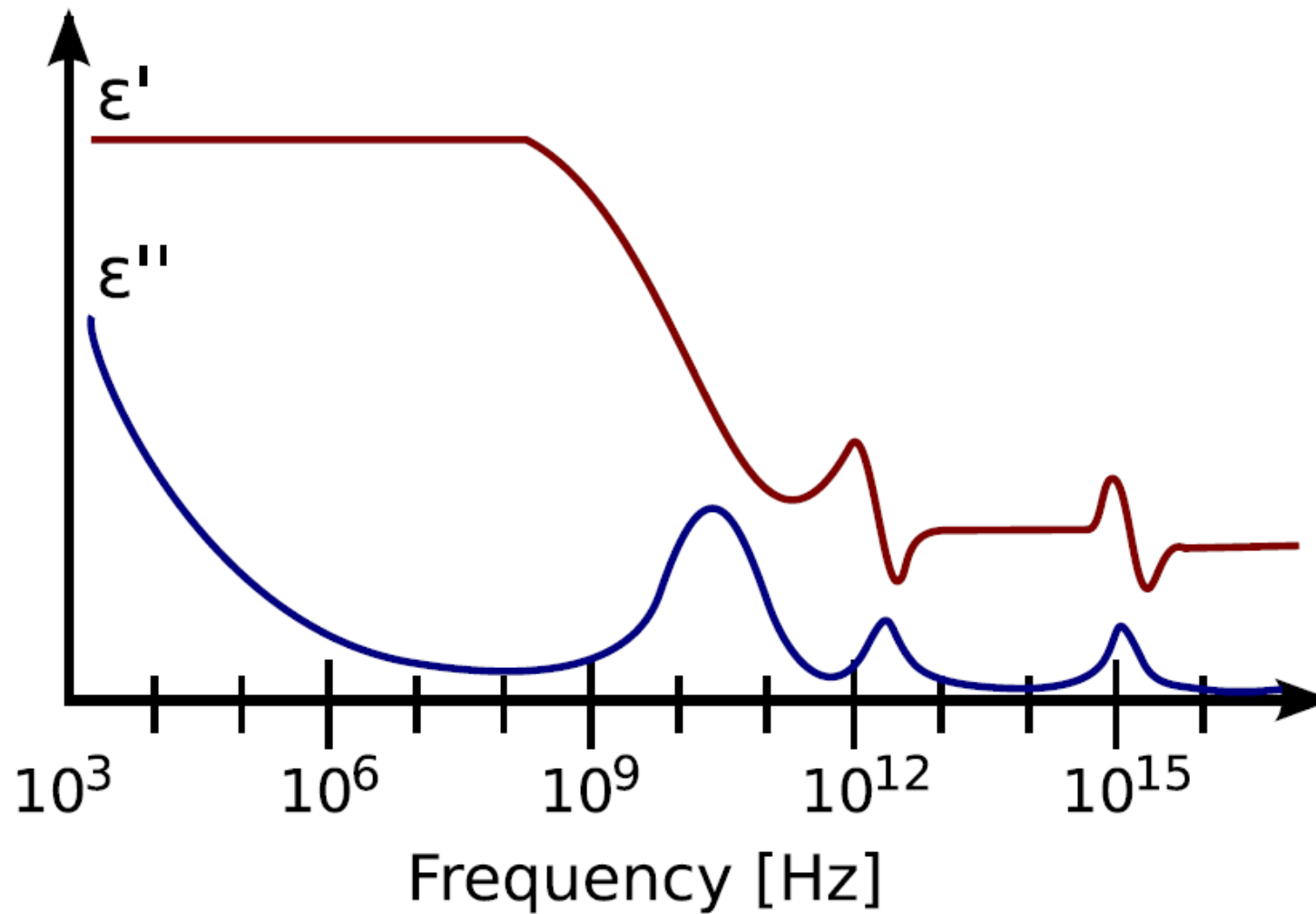


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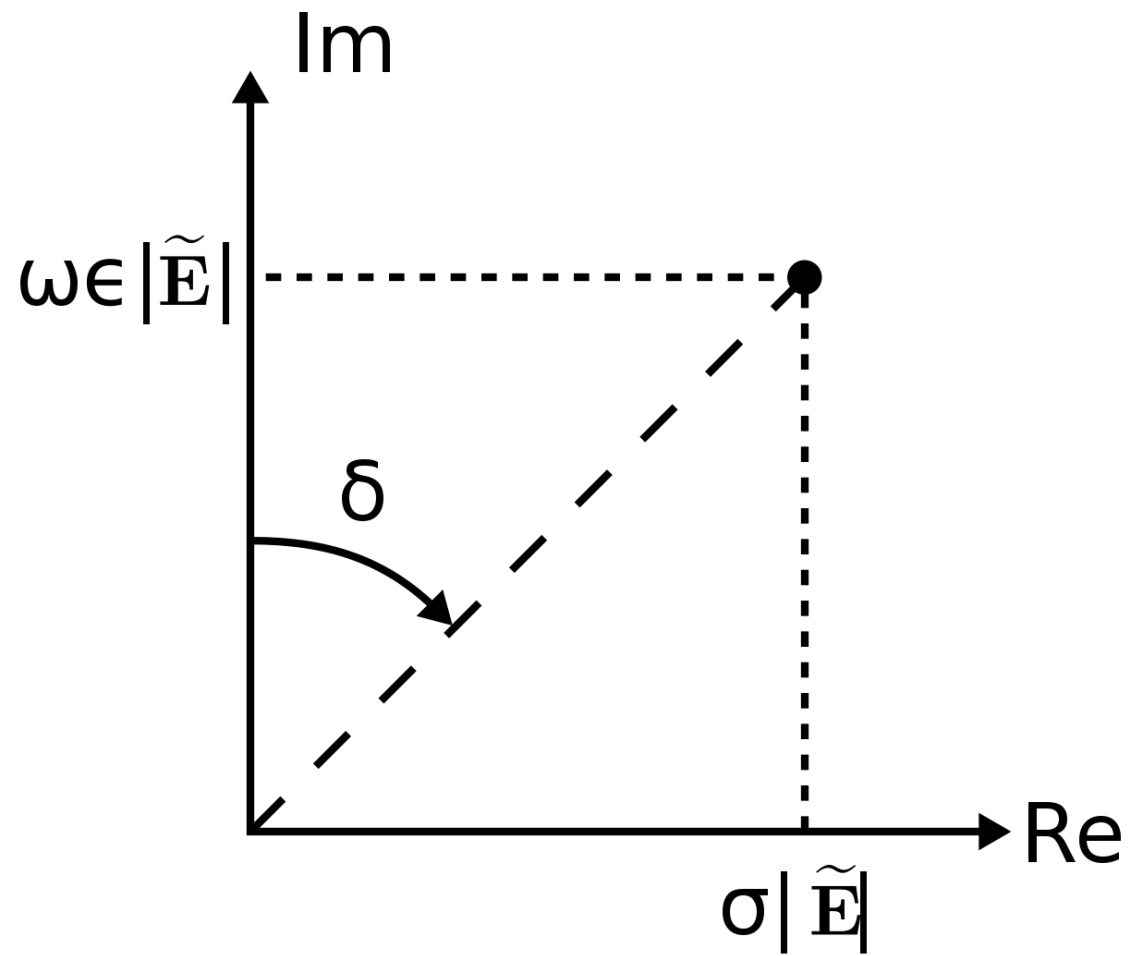


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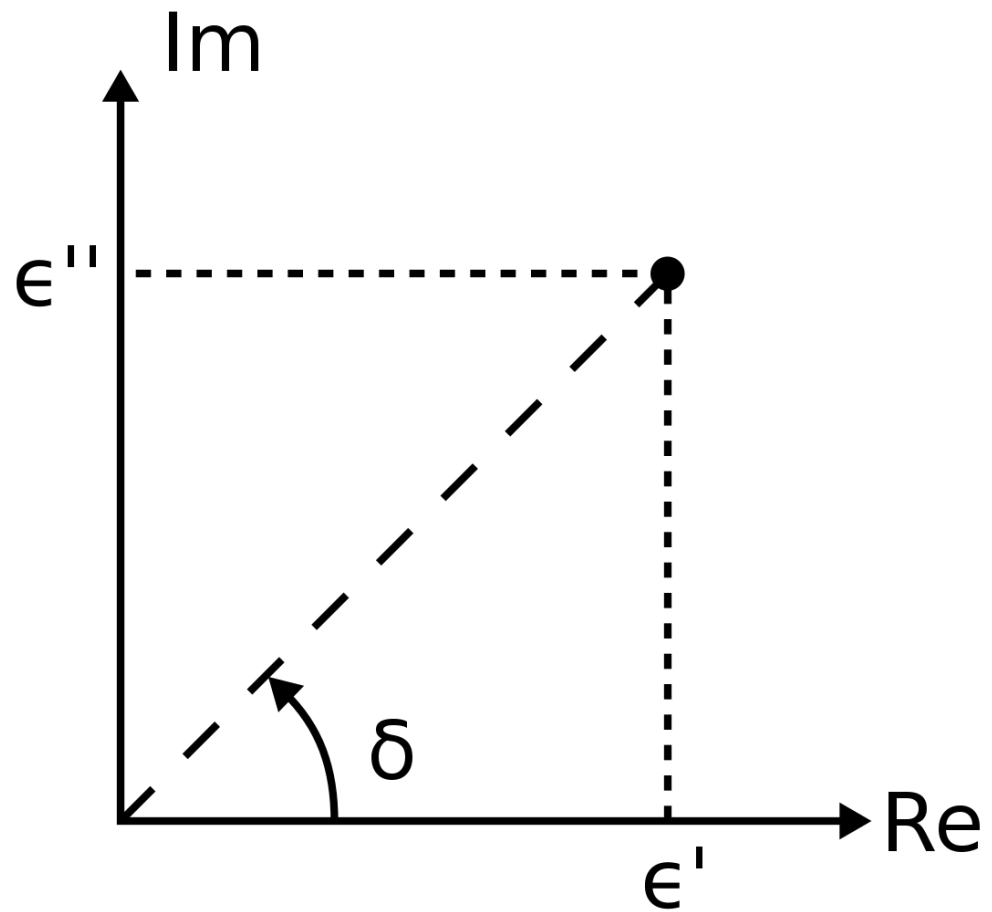


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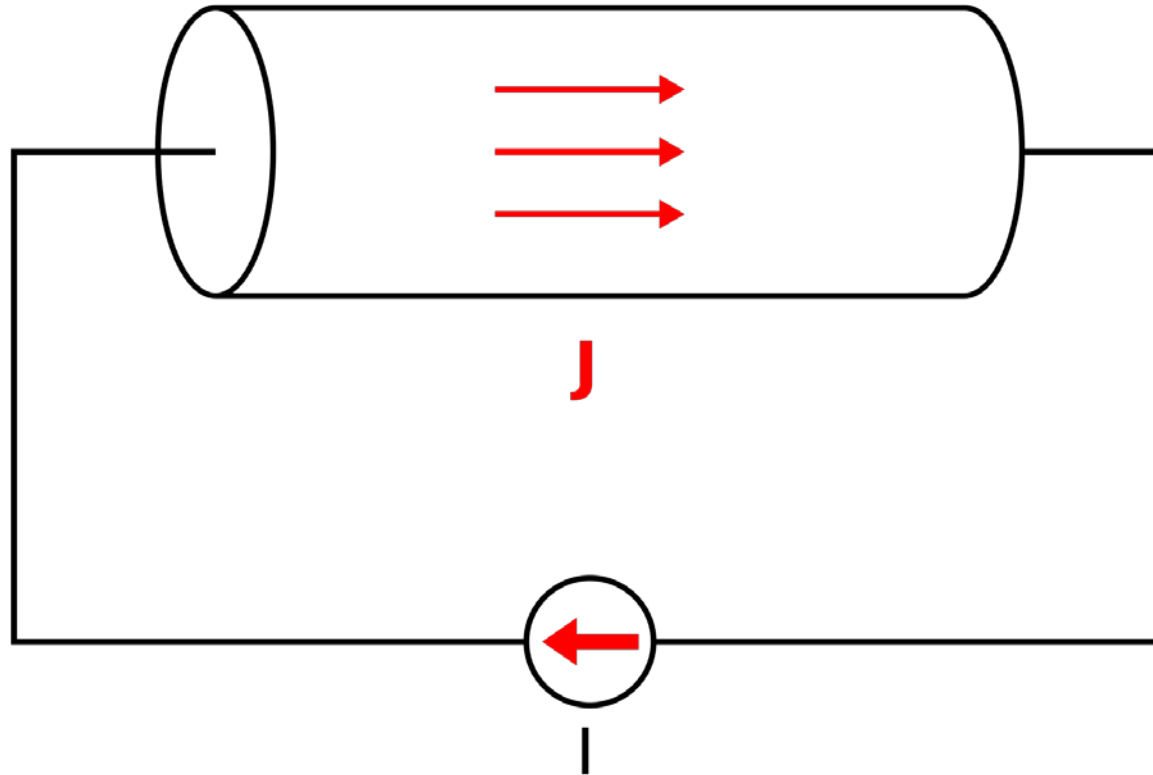


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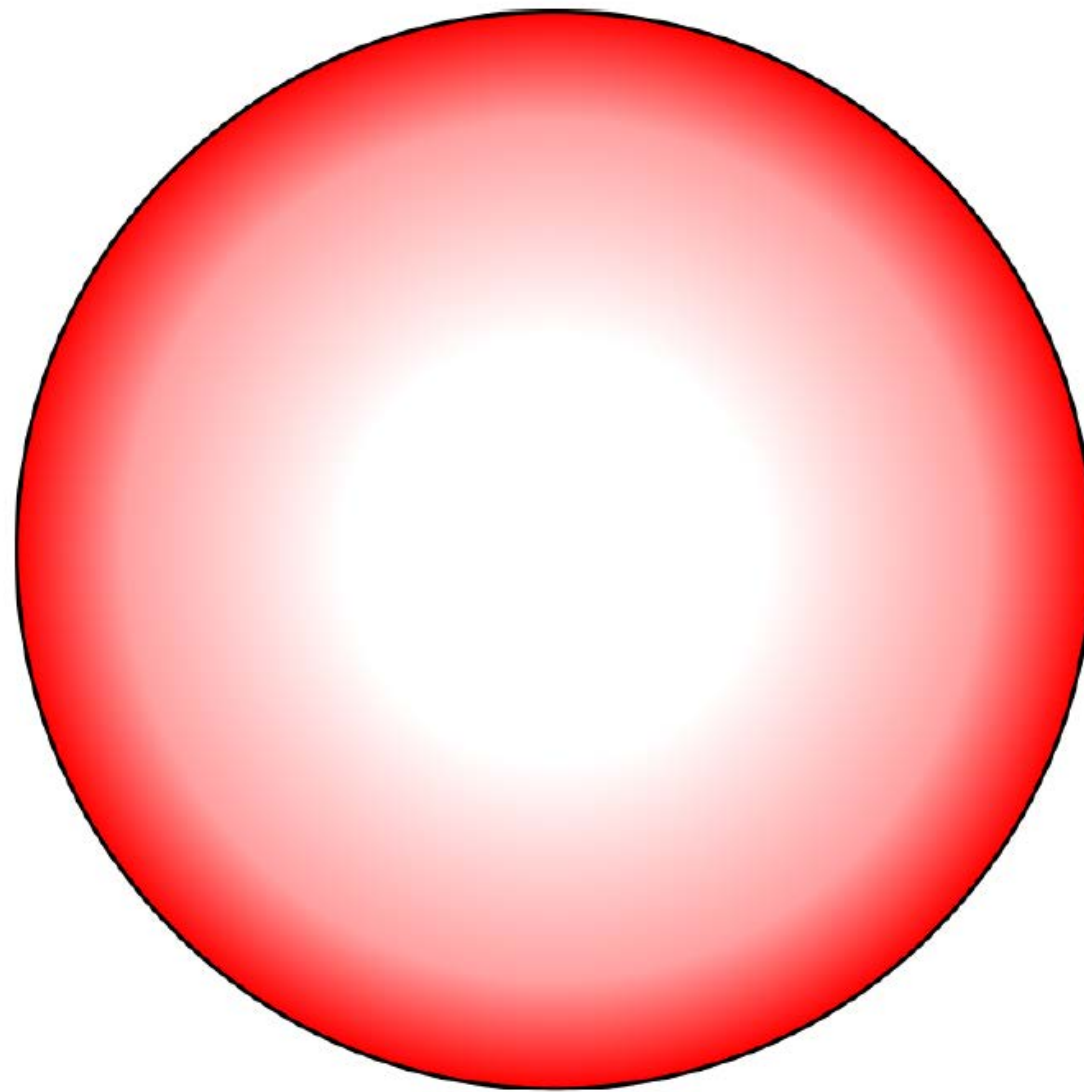


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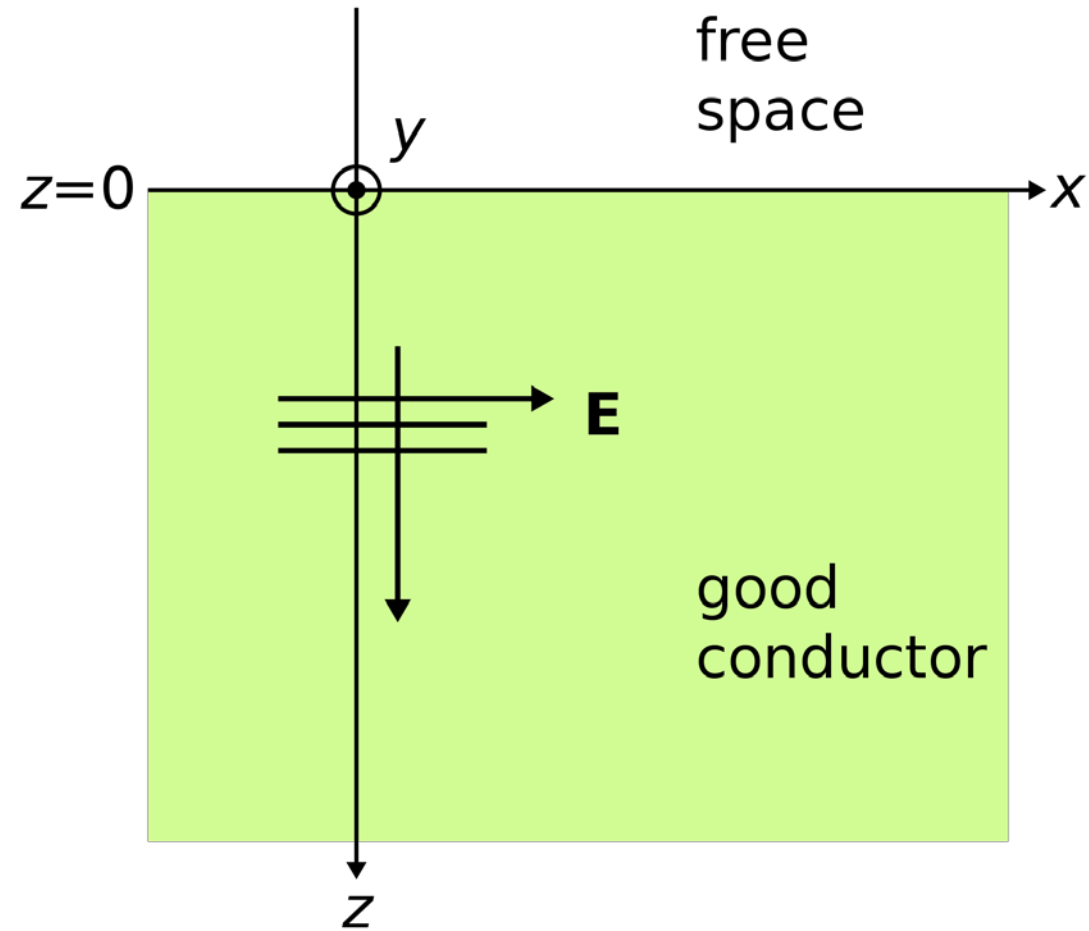


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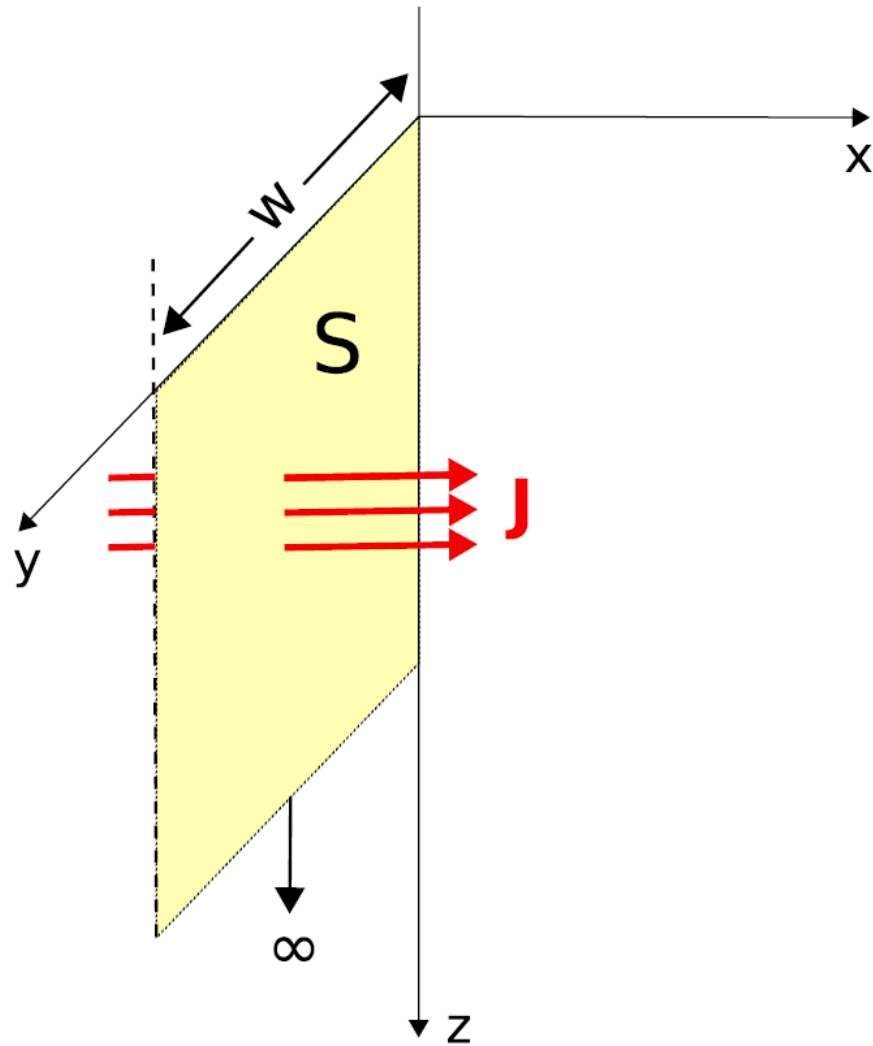


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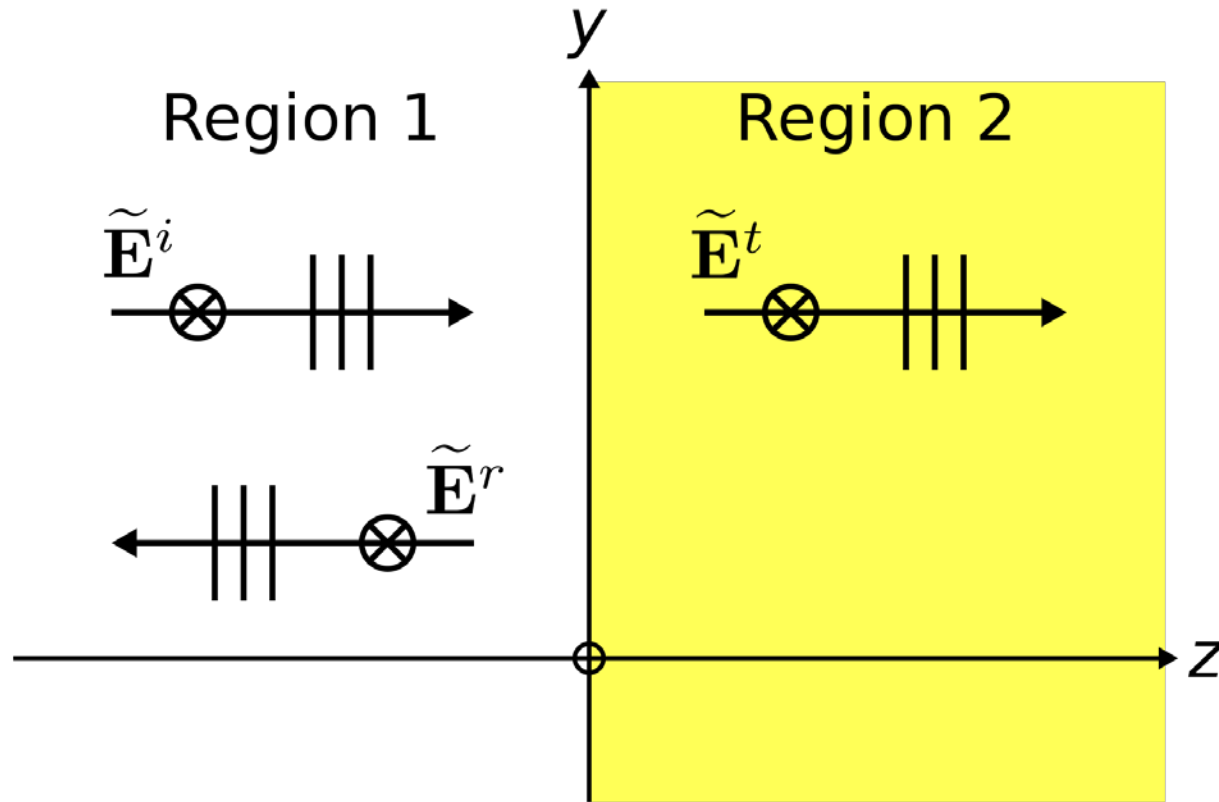


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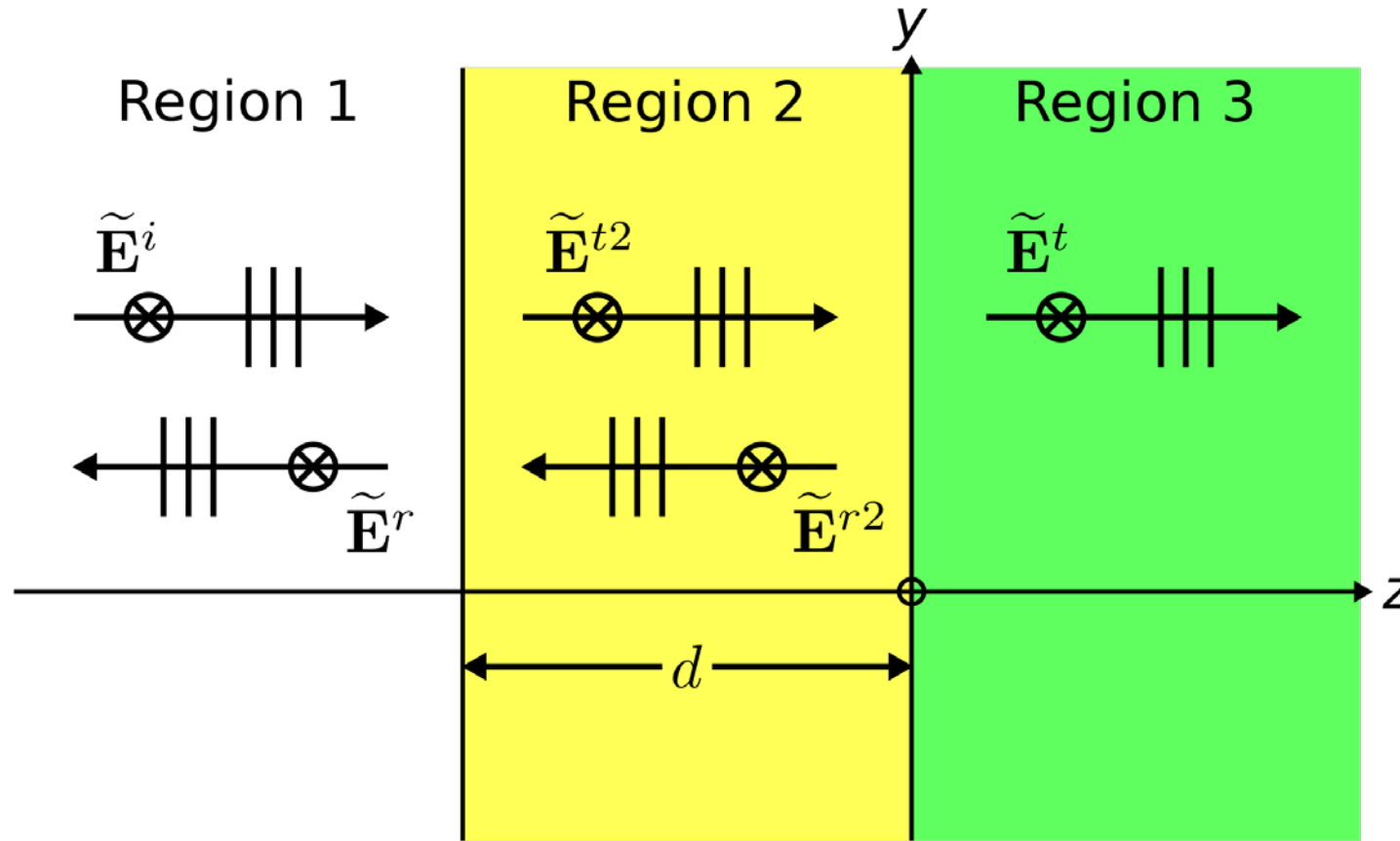


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	Electric Field Intensity	Magnetic Field Intensity	Region of Validity
Region 1	$\tilde{\mathbf{E}}^i(z) = \hat{\mathbf{x}}E_0^i e^{-j\beta_1 z}$ $\tilde{\mathbf{E}}^r(z) = \hat{\mathbf{x}}B e^{+j\beta_1 z}$	$\tilde{\mathbf{H}}^i(z) = +\hat{\mathbf{y}} (E_0^i/\eta_1) e^{-j\beta_1 z}$ $\tilde{\mathbf{H}}^r(z) = -\hat{\mathbf{y}} (B/\eta_1) e^{+j\beta_1 z}$	$z \leq -d$
Region 2	$\tilde{\mathbf{E}}^{t2}(z) = \hat{\mathbf{x}}C e^{-j\beta_2 z}$ $\tilde{\mathbf{E}}^{r2}(z) = \hat{\mathbf{x}}D e^{+j\beta_2 z}$	$\tilde{\mathbf{H}}^{t2}(z) = +\hat{\mathbf{y}} (C/\eta_2) e^{-j\beta_2 z}$ $\tilde{\mathbf{H}}^{r2}(z) = -\hat{\mathbf{y}} (D/\eta_2) e^{+j\beta_2 z}$	$-d \leq z \leq 0$
Region 3	$\tilde{\mathbf{E}}^t(z) = \hat{\mathbf{x}}F e^{-j\beta_3 z}$	$\tilde{\mathbf{H}}^t(z) = +\hat{\mathbf{y}} (F/\eta_3) e^{-j\beta_3 z}$	$z \geq 0$

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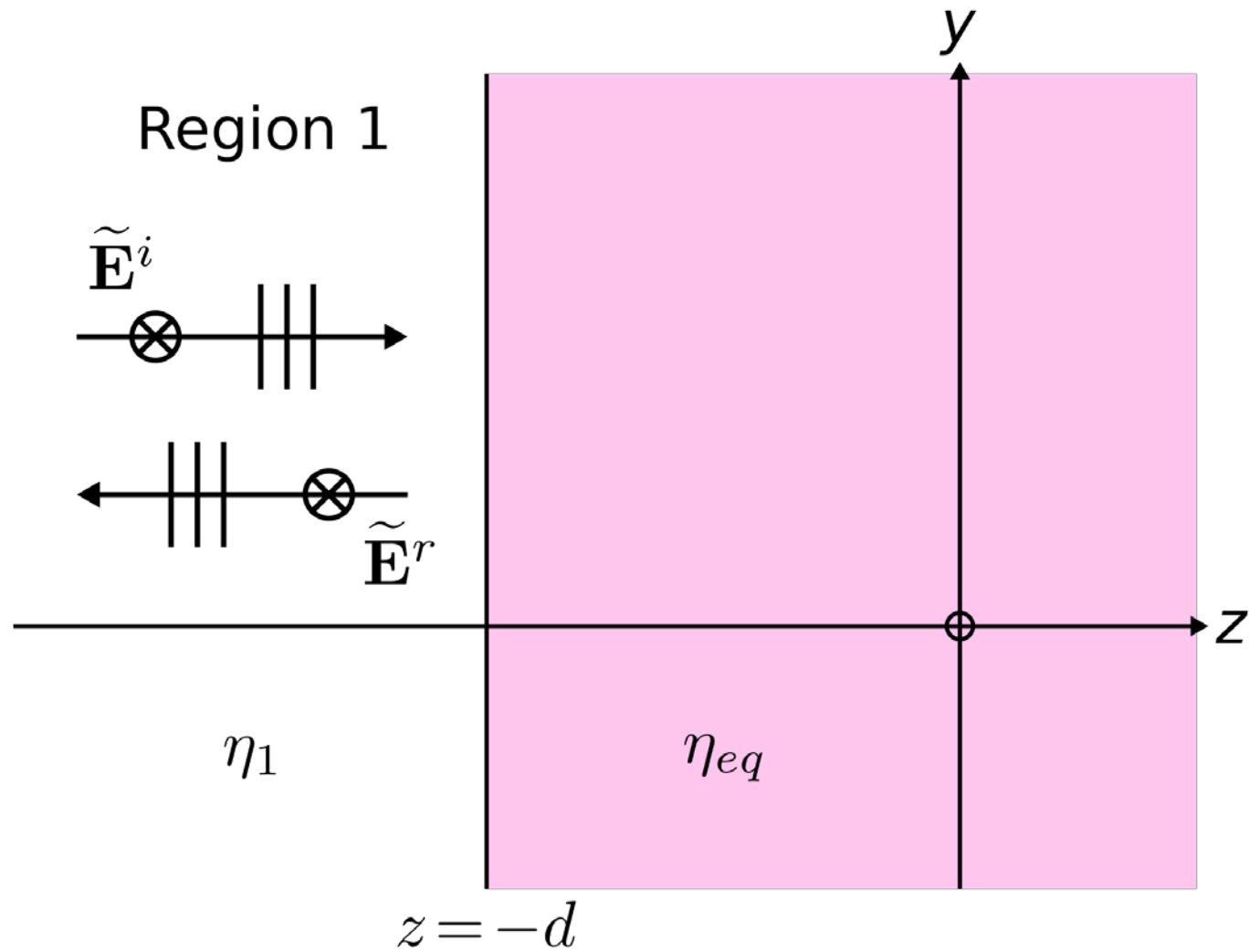


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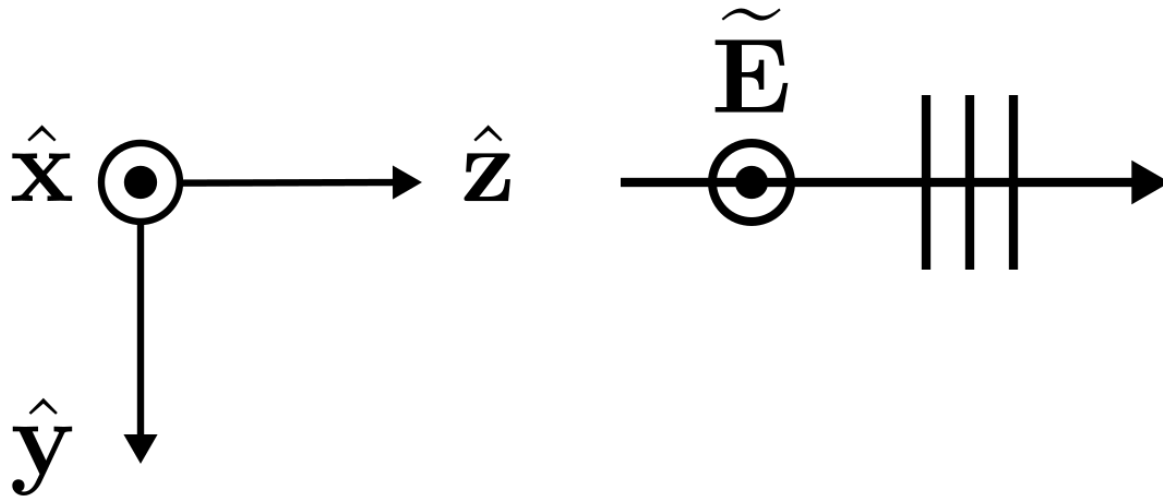


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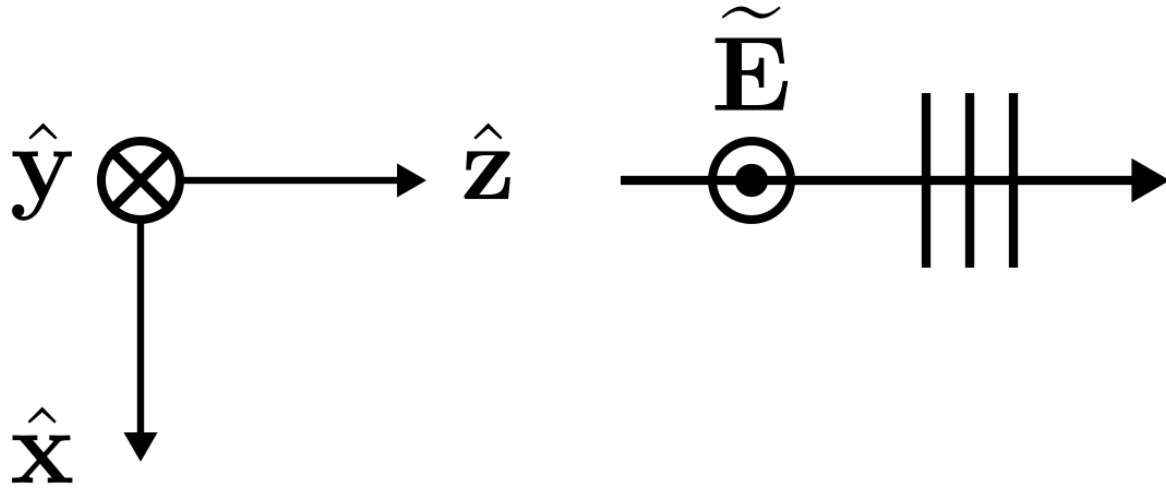


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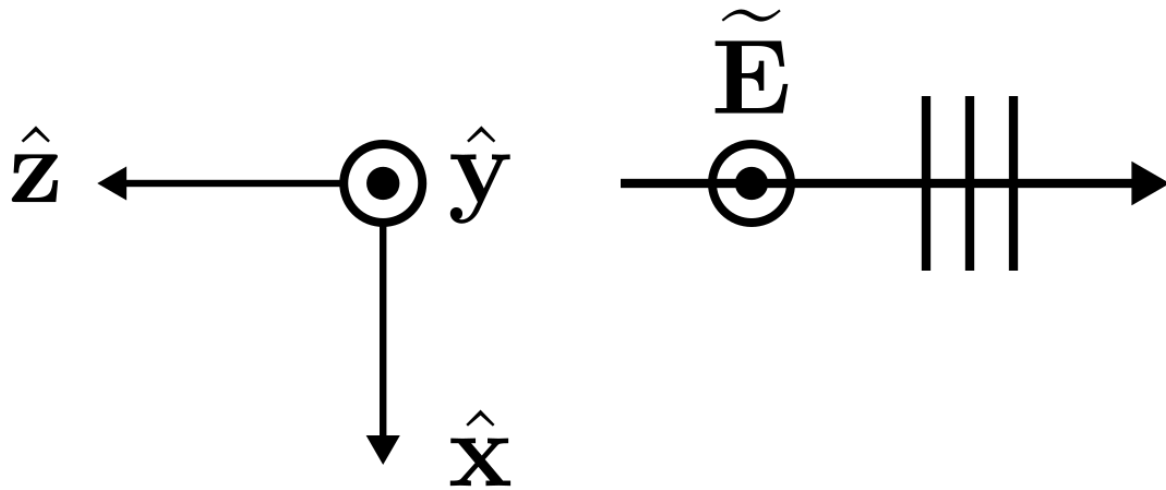


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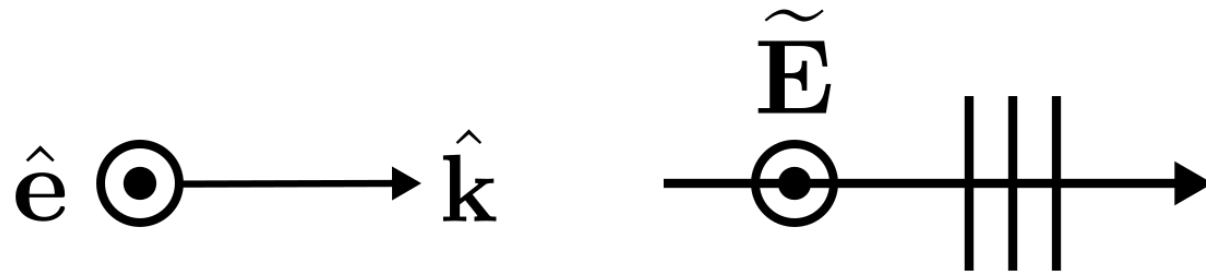


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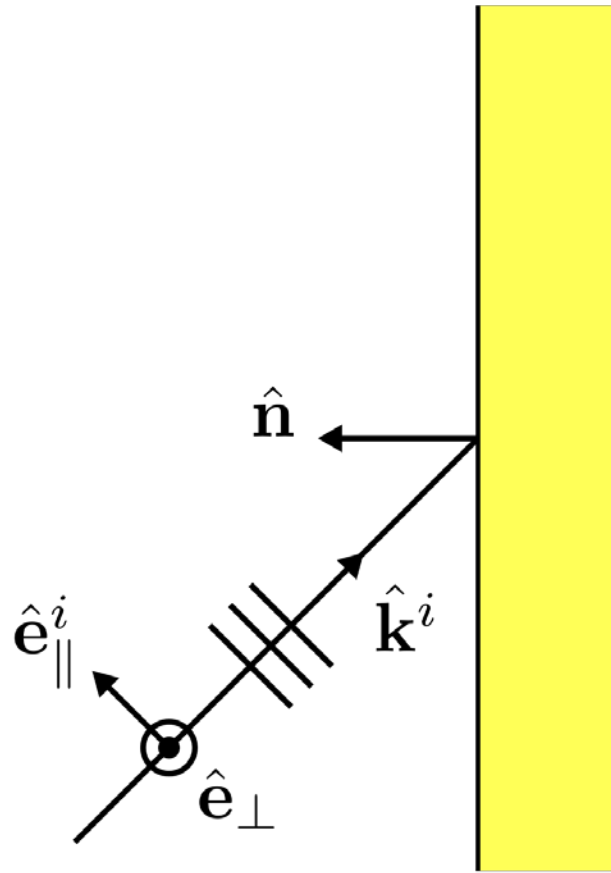


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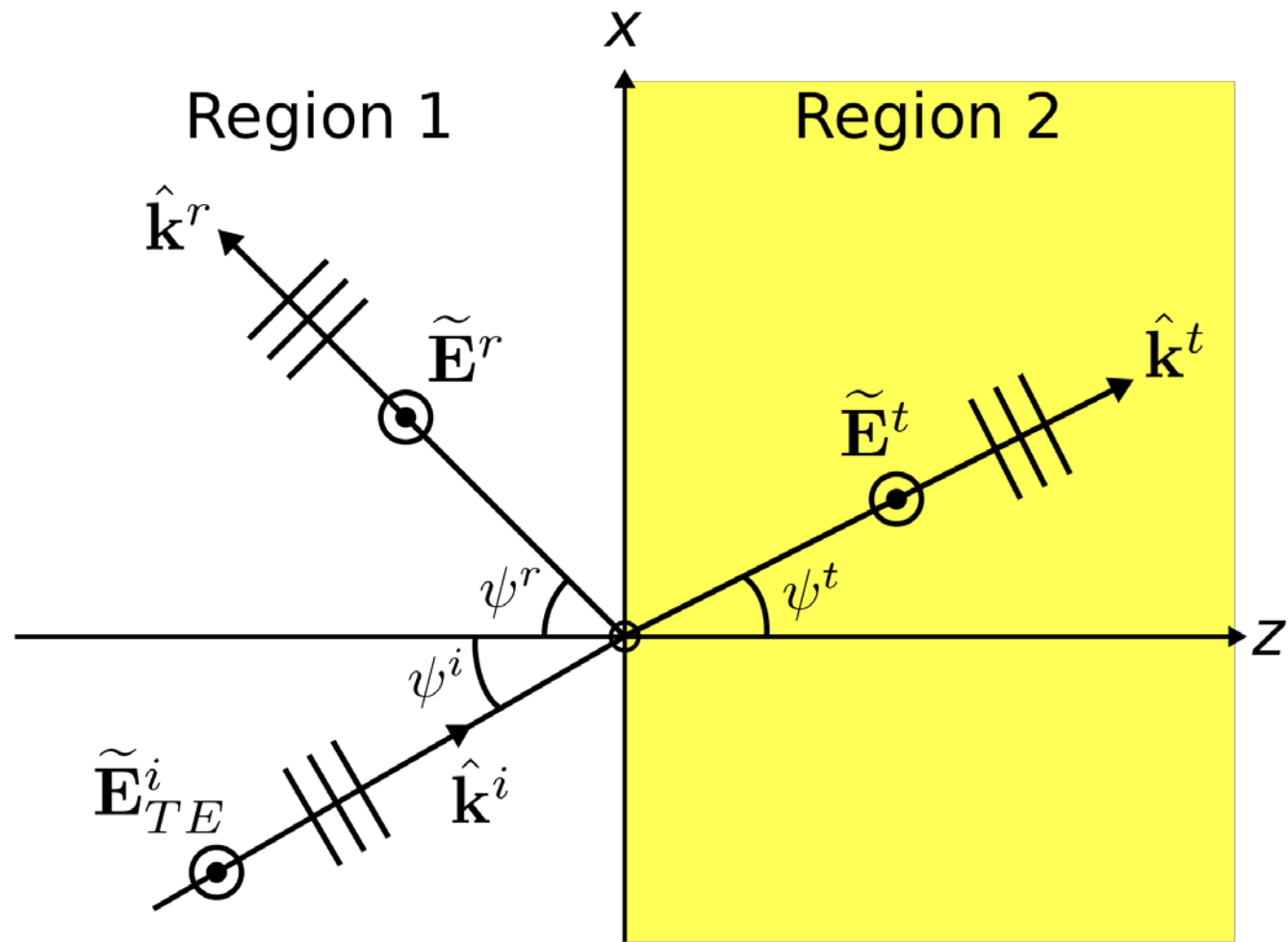


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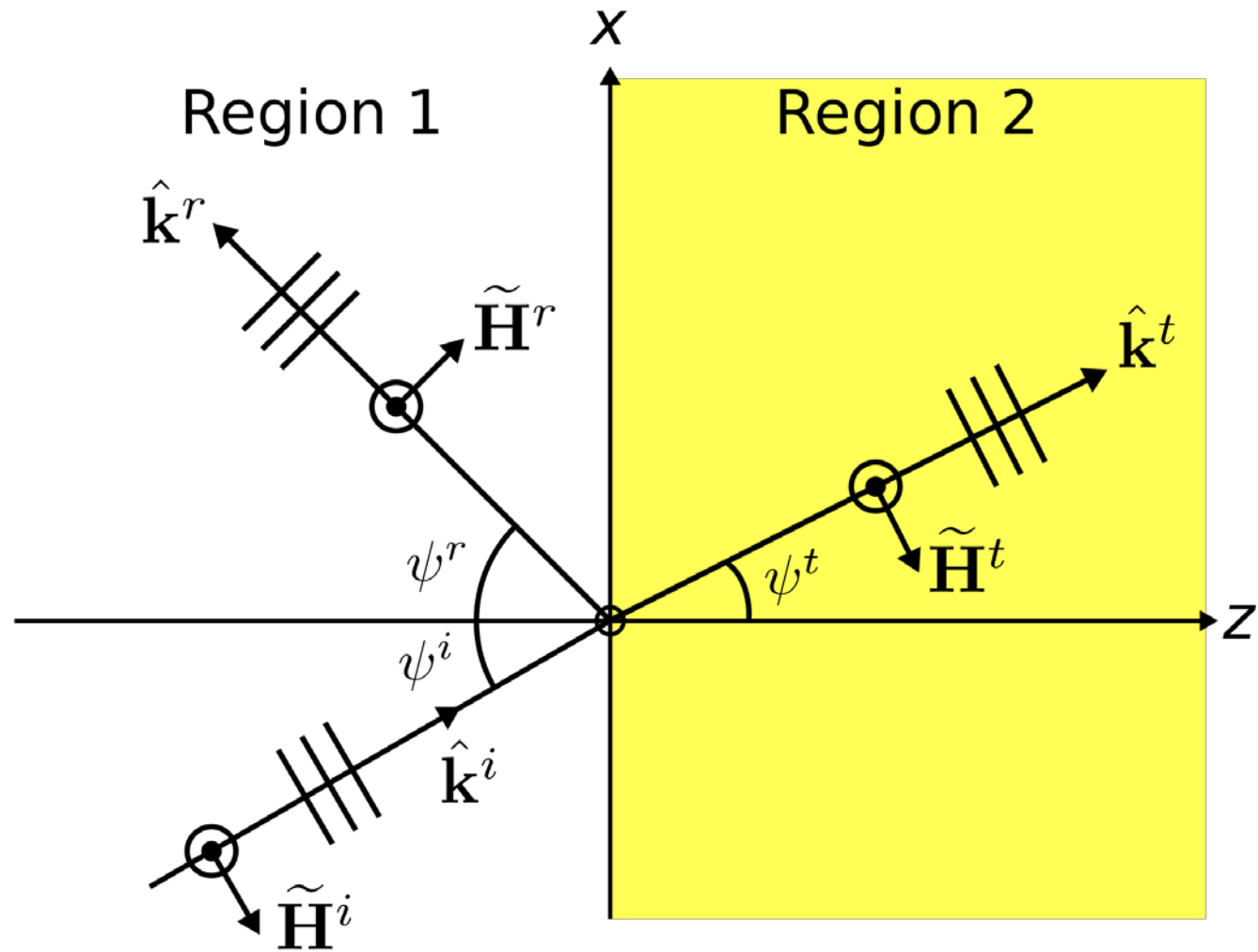


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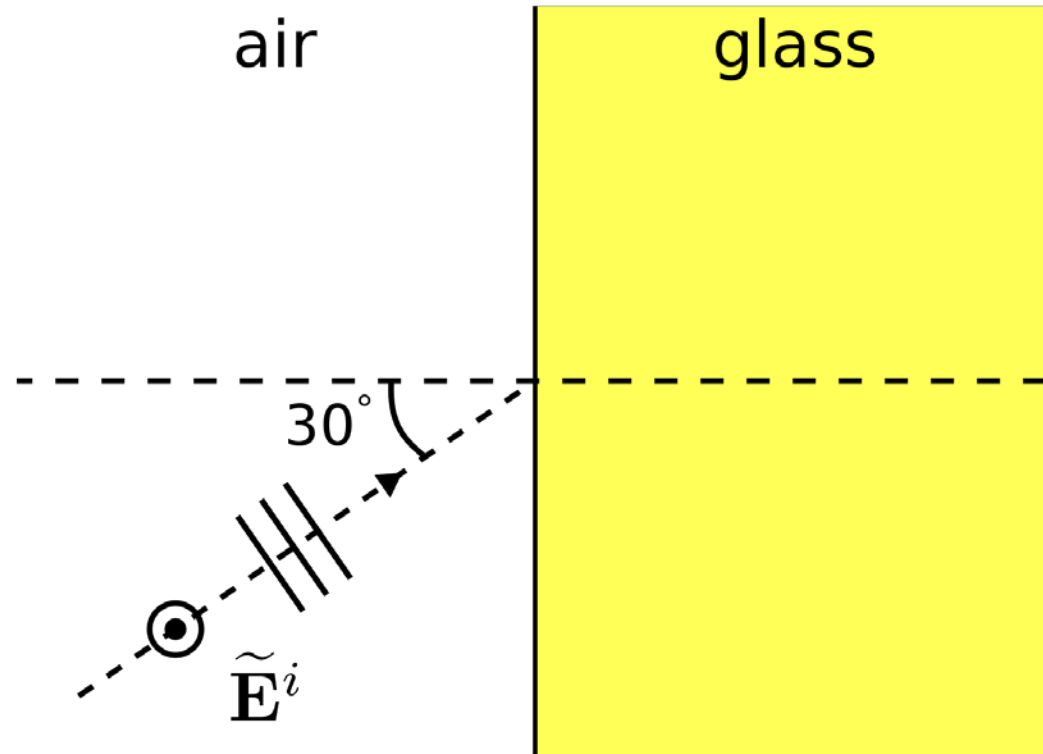


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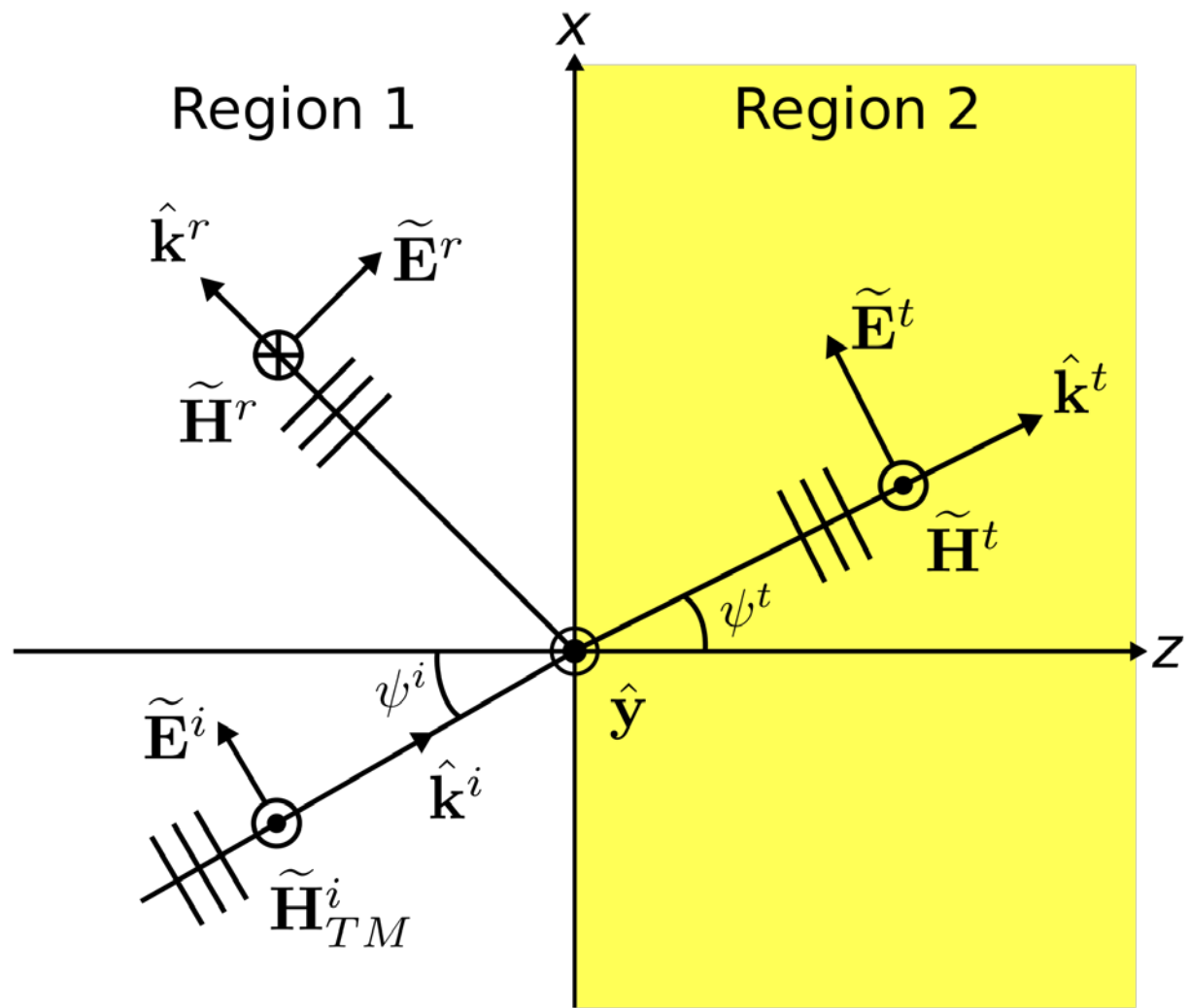


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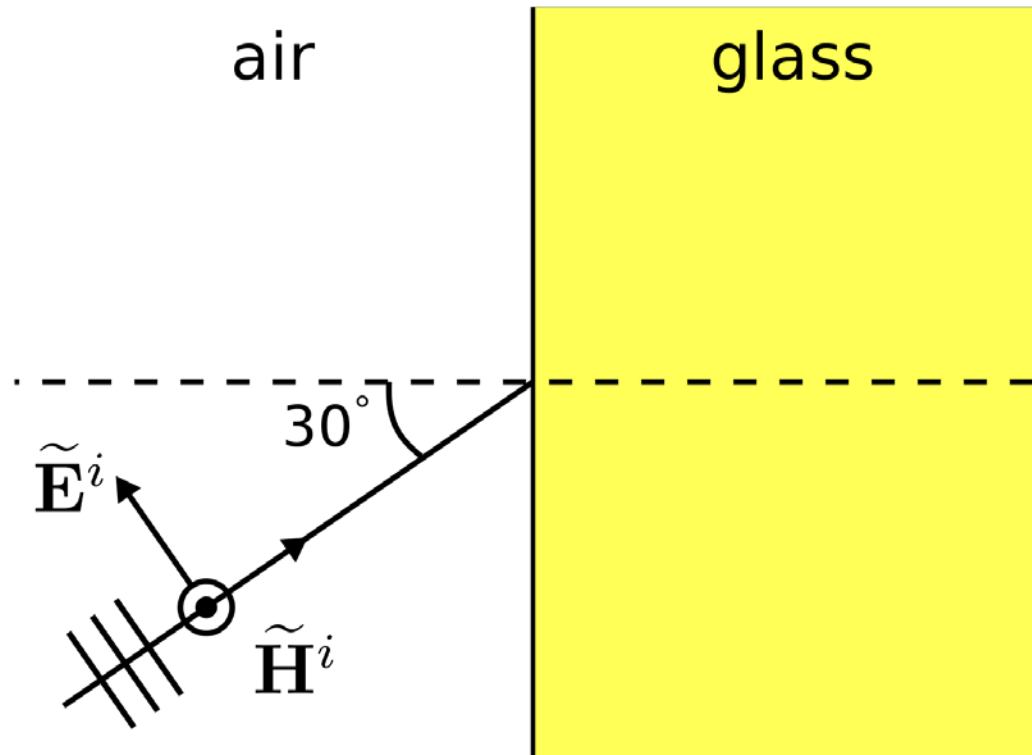


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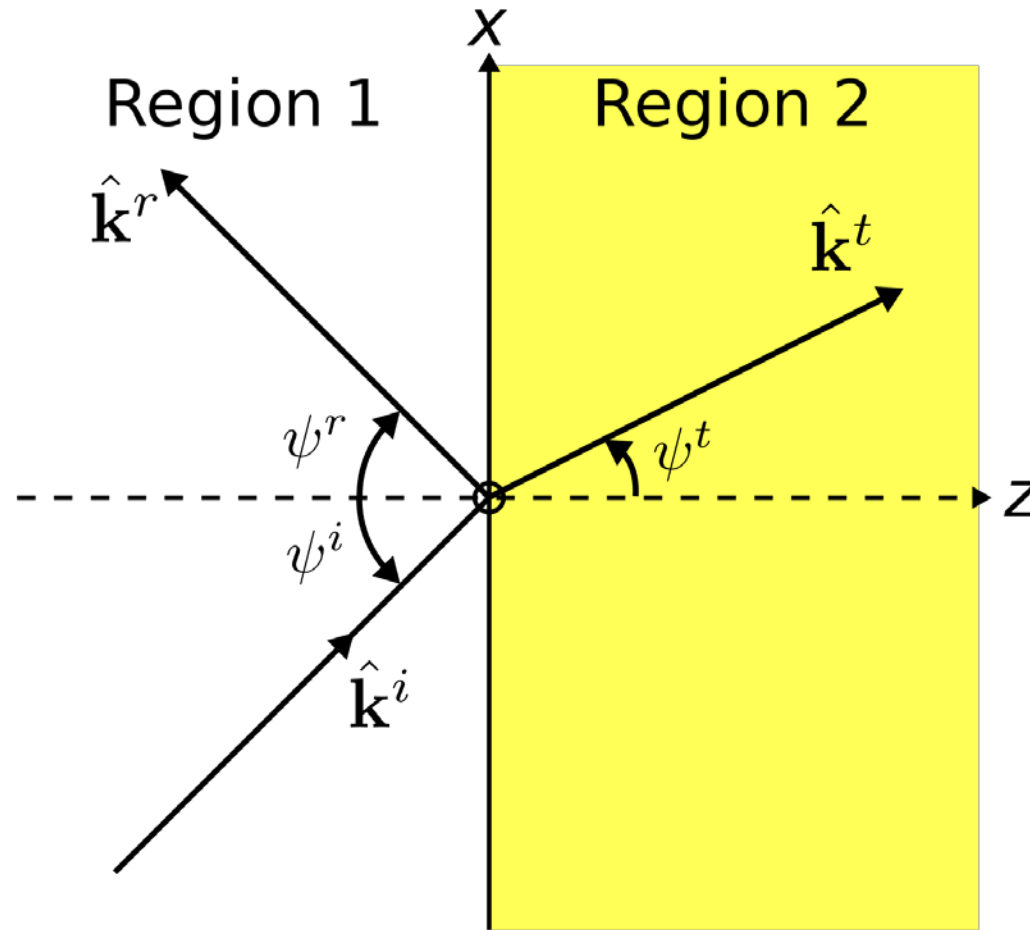


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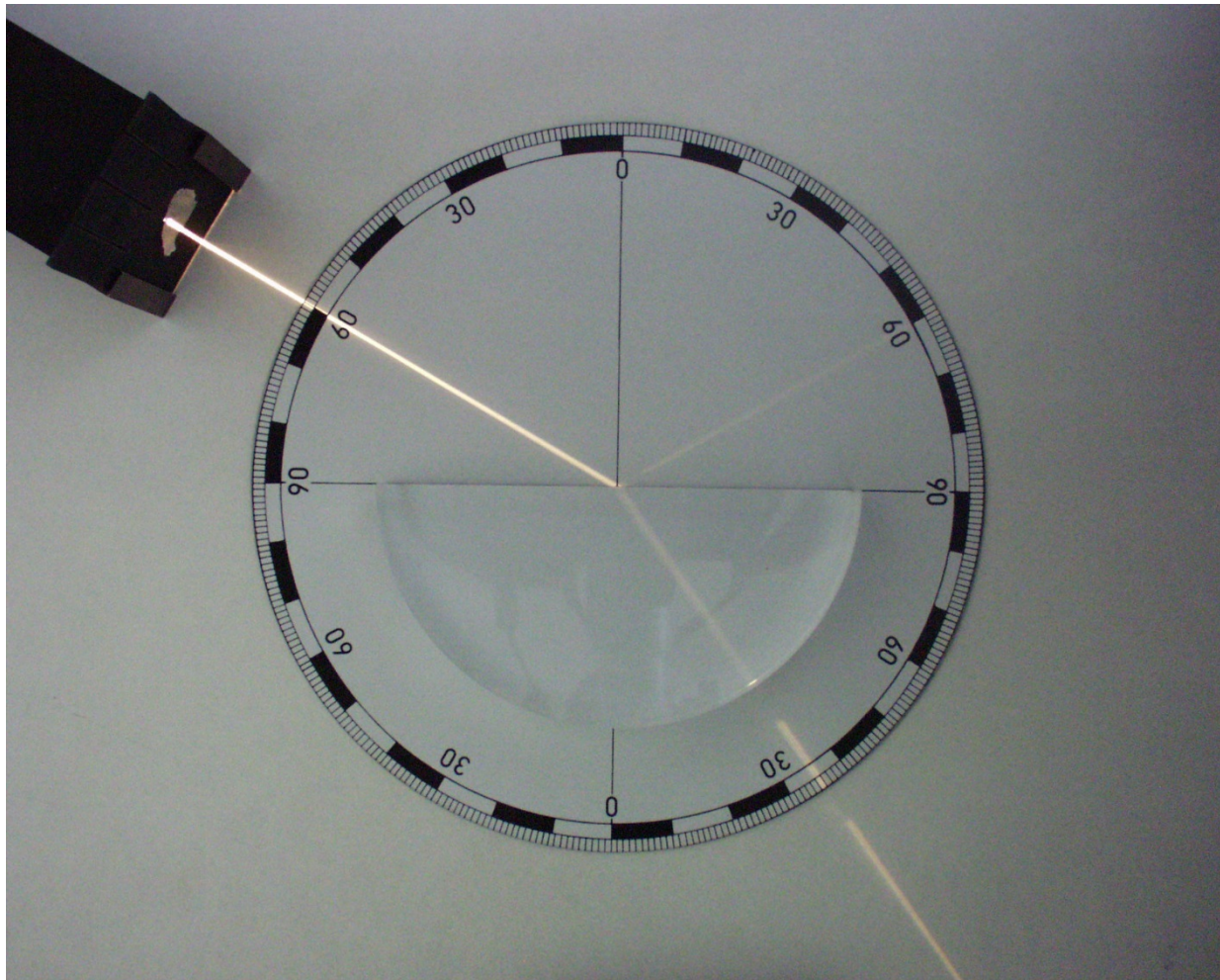
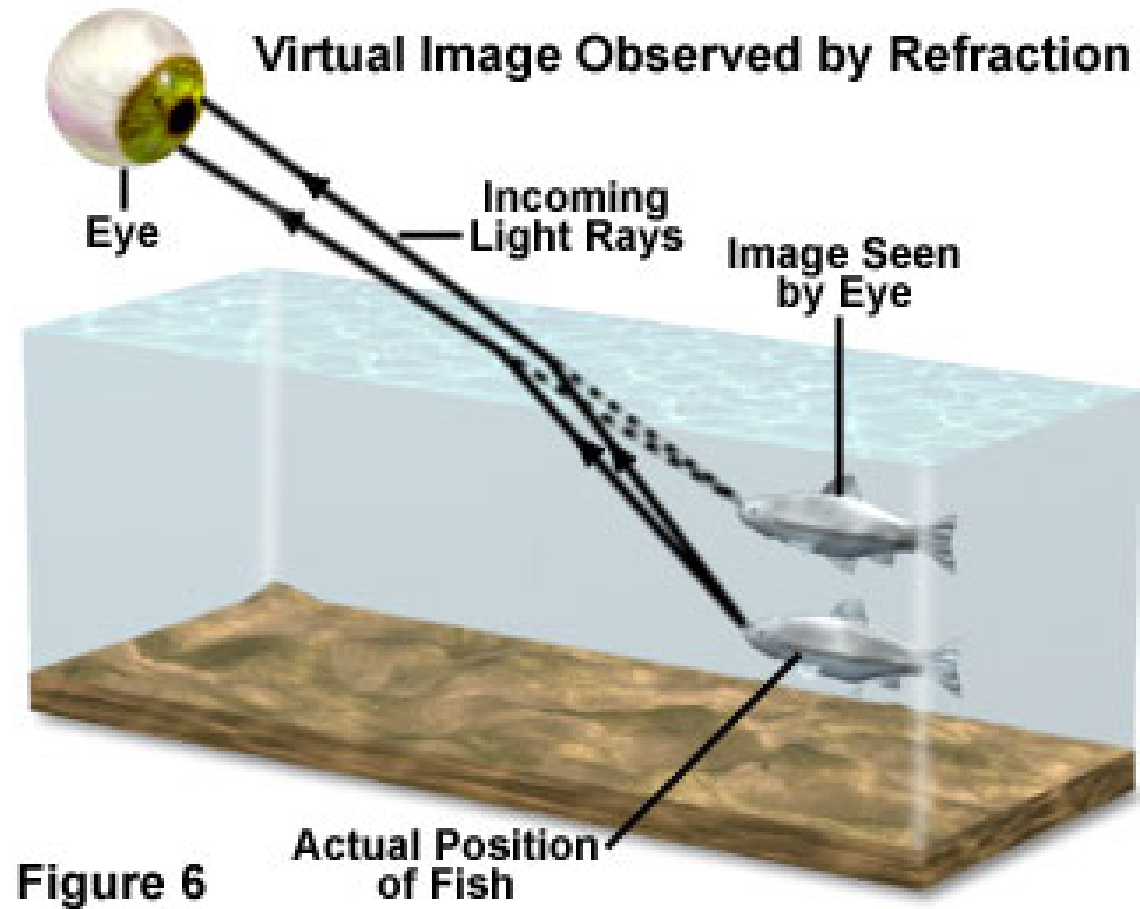


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**Figure 6**

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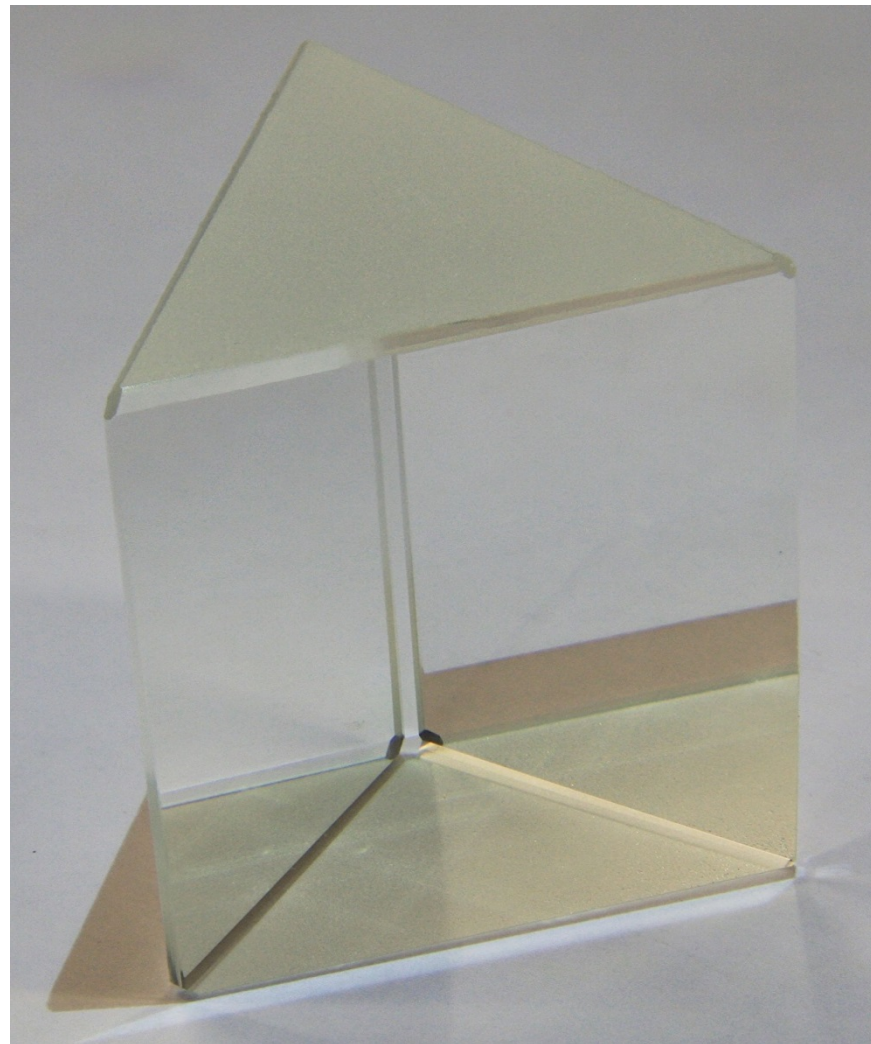


Fig. 5.17: © D-Kuru, [https://commons.wikimedia.org/wiki/File:Prism-side-fs\\_PNr%C2%B00117.jpg](https://commons.wikimedia.org/wiki/File:Prism-side-fs_PNr%C2%B00117.jpg), CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/>).

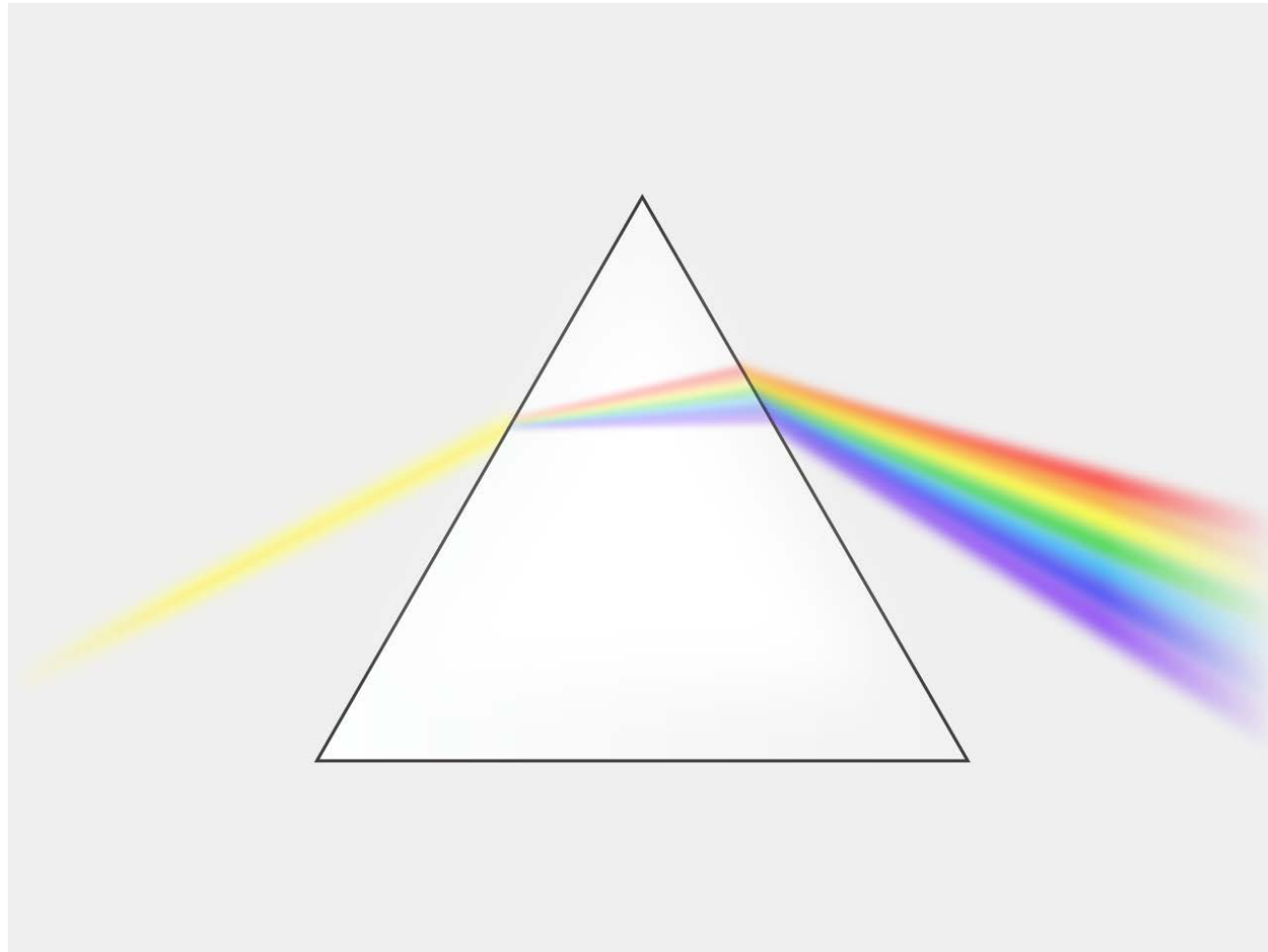


Fig. 5.18: © Suidroot, <https://commons.wikimedia.org/wiki/File:Prism-rainbow.svg>, CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

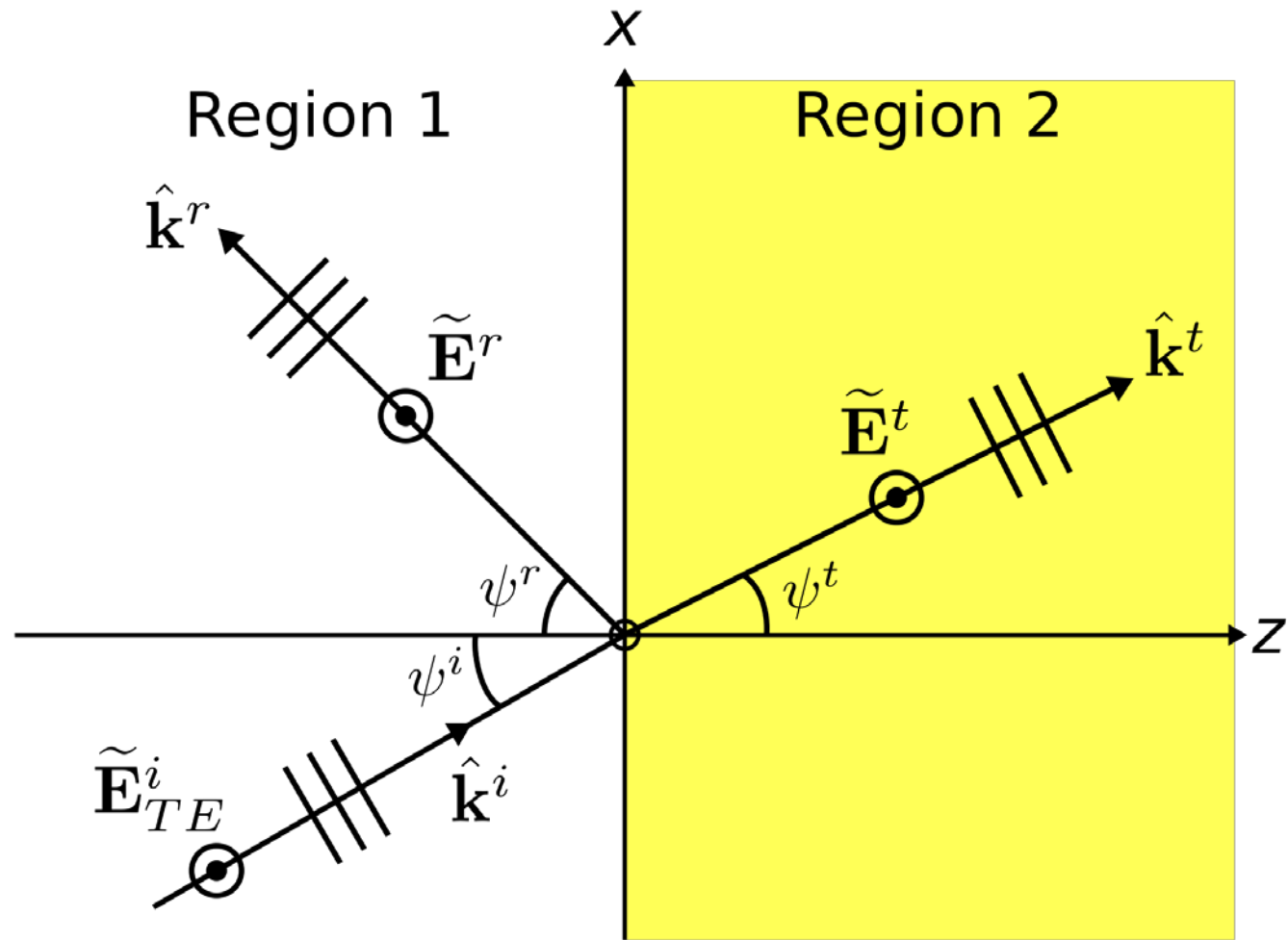


Fig. 5.19: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:TE-polarized upw incident on planar boundary.svg](https://commons.wikimedia.org/wiki/File:TE-polarized_upw_incident_on_planar_boundary.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

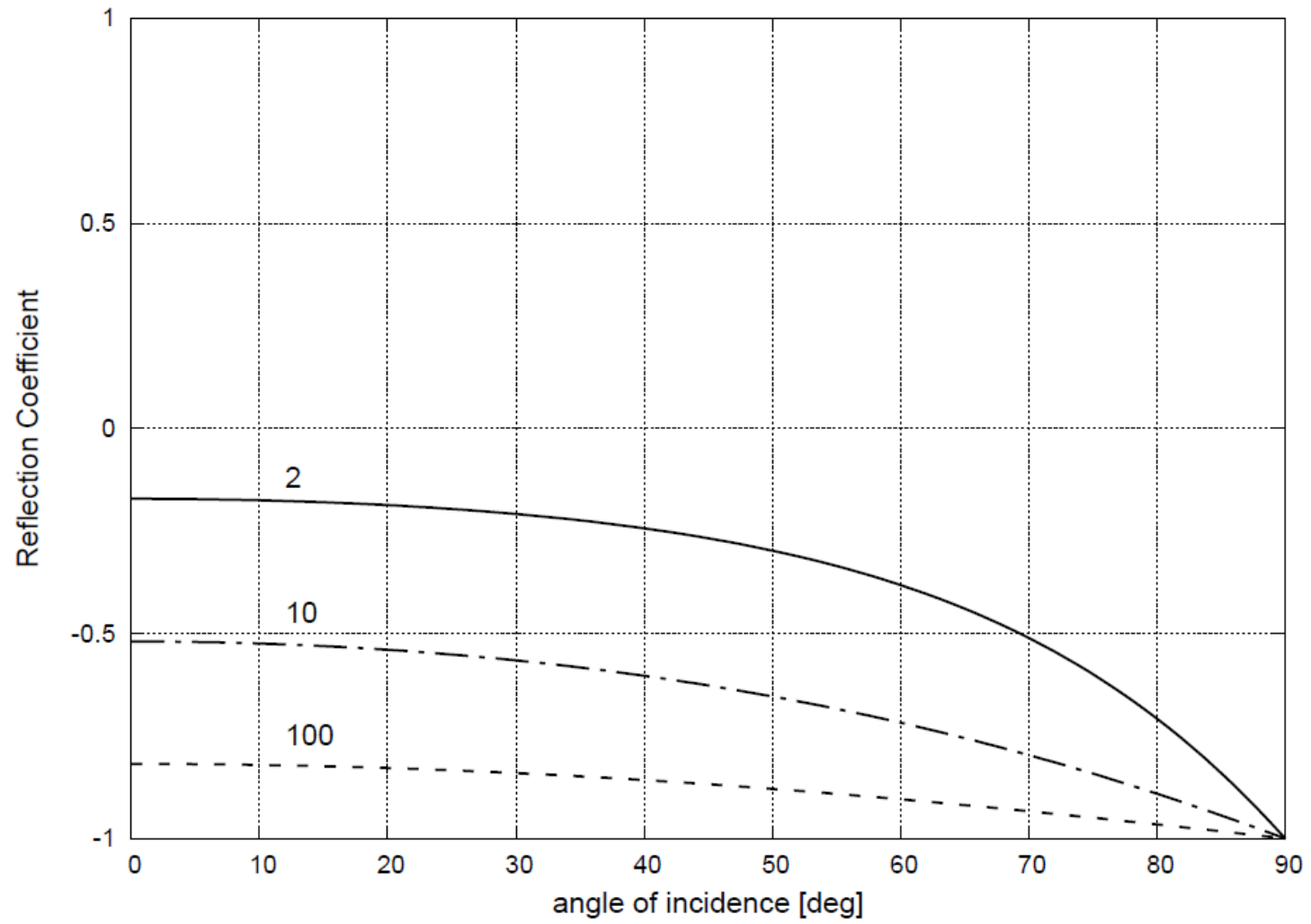


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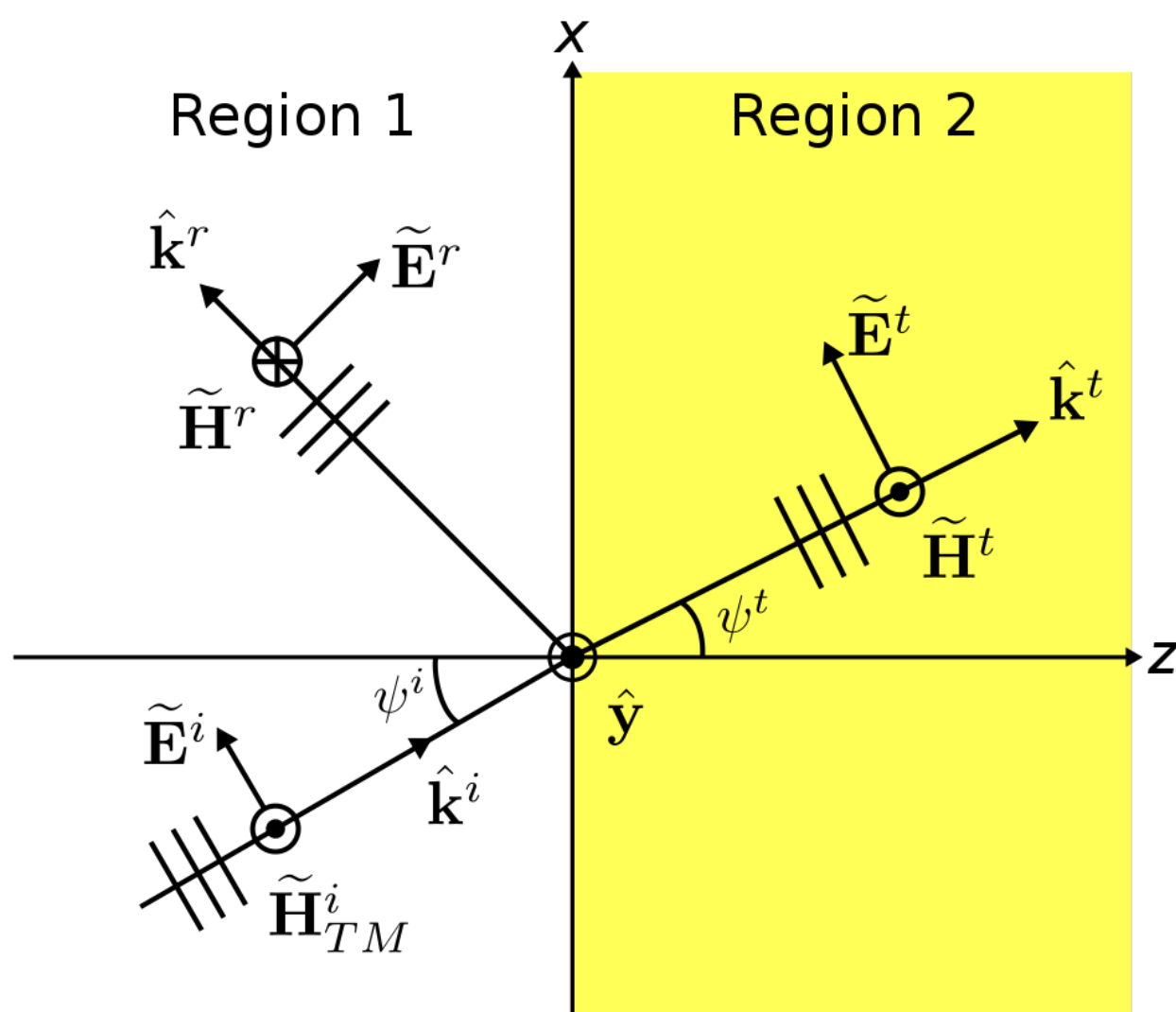


Fig. 5.21: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:TM-polarized upw incident on planar boundary.svg](https://commons.wikimedia.org/wiki/File:TM-polarized_upw_incident_on_planar_boundary.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

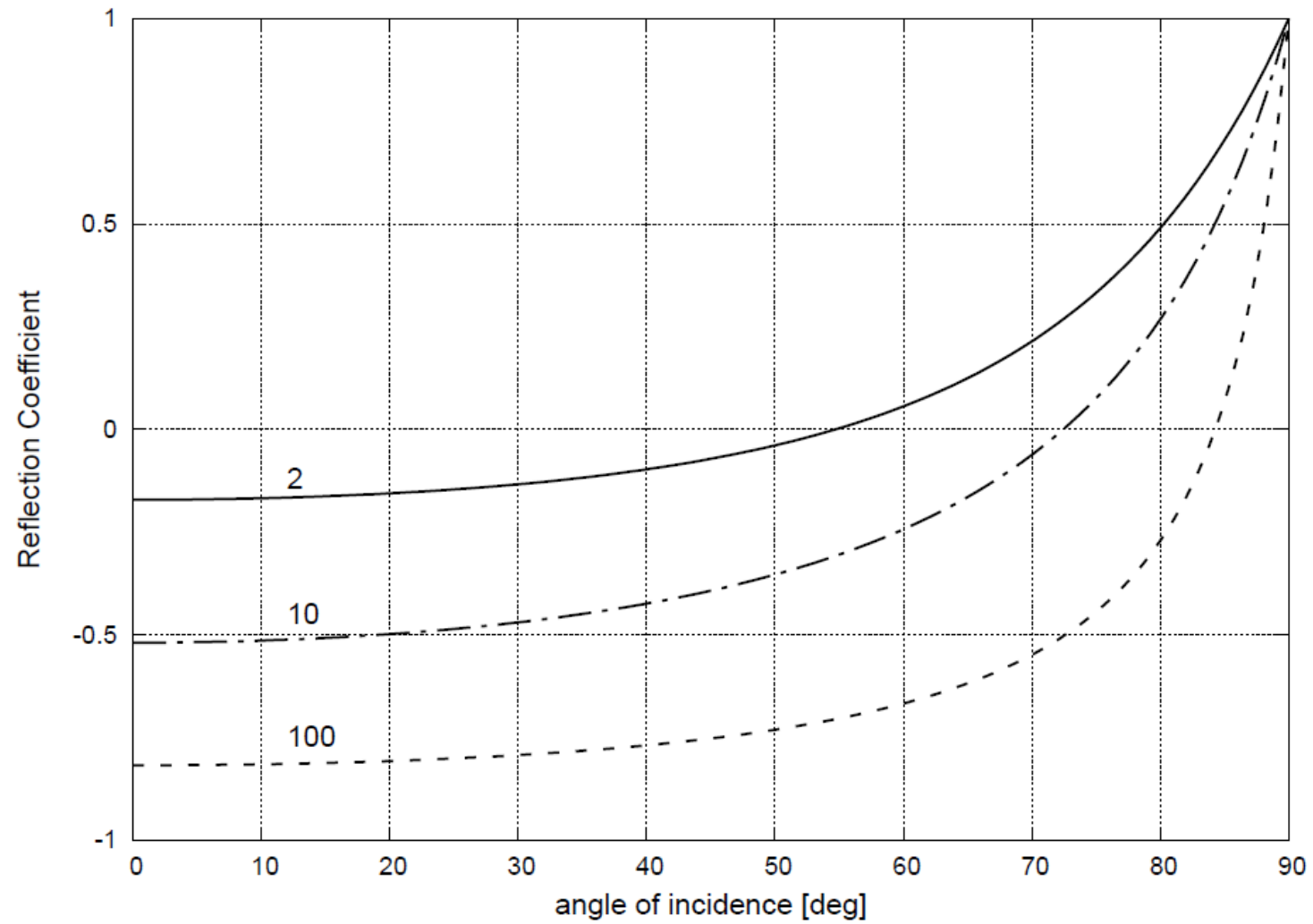


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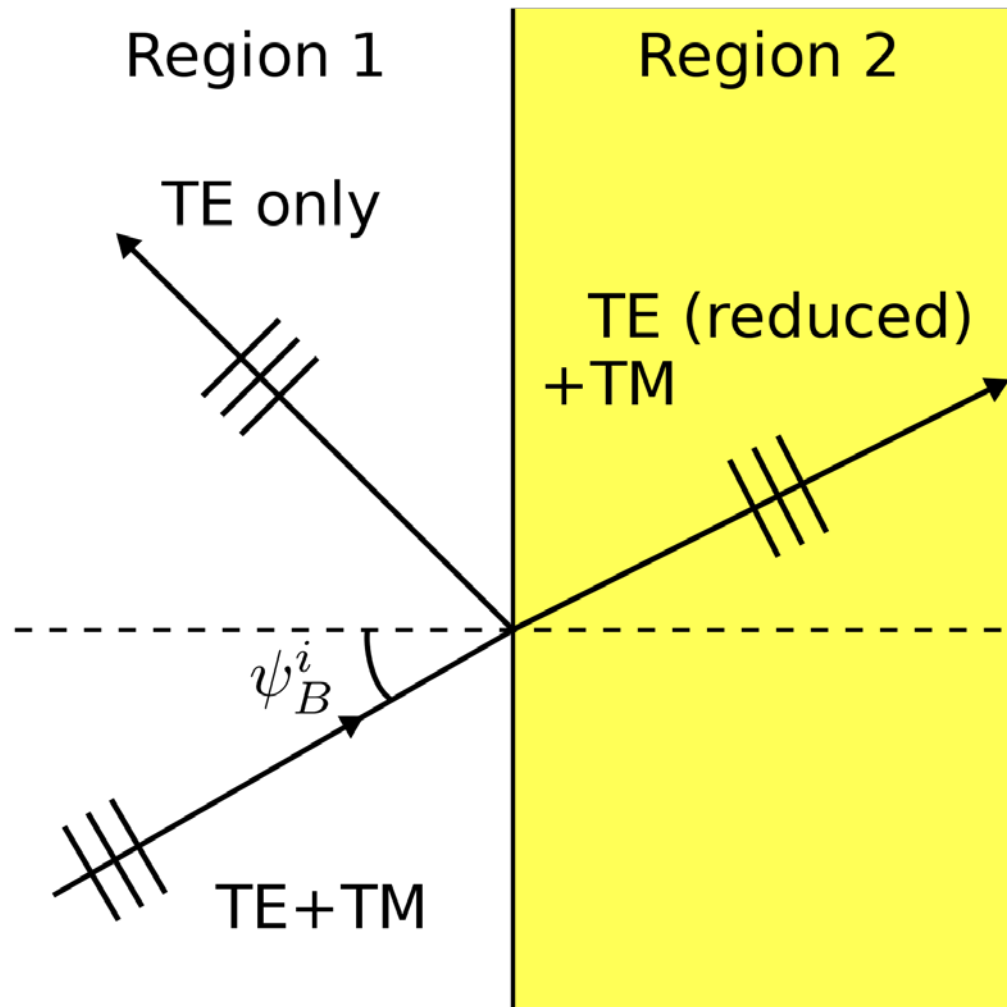


Fig. 5.23: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Reflection\\_of\\_plane\\_wave\\_incidence\\_angle\\_equals\\_polarizing\\_angle.svg](https://commons.wikimedia.org/wiki/File:Reflection_of_plane_wave_incidence_angle_equals_polarizing_angle.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

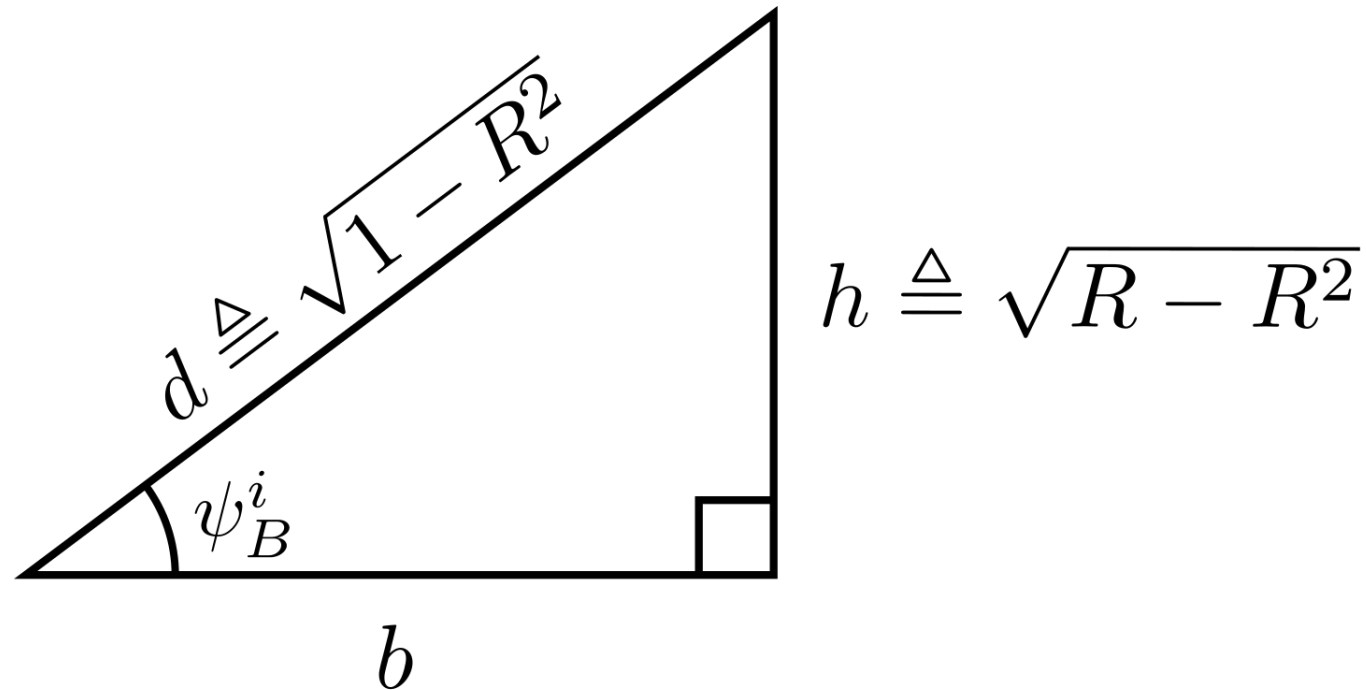


Fig. 5.24: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Brewster%E2%80%99s\\_angle\\_for\\_non-magnetic\\_media.svg](https://commons.wikimedia.org/wiki/File:Brewster%E2%80%99s_angle_for_non-magnetic_media.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

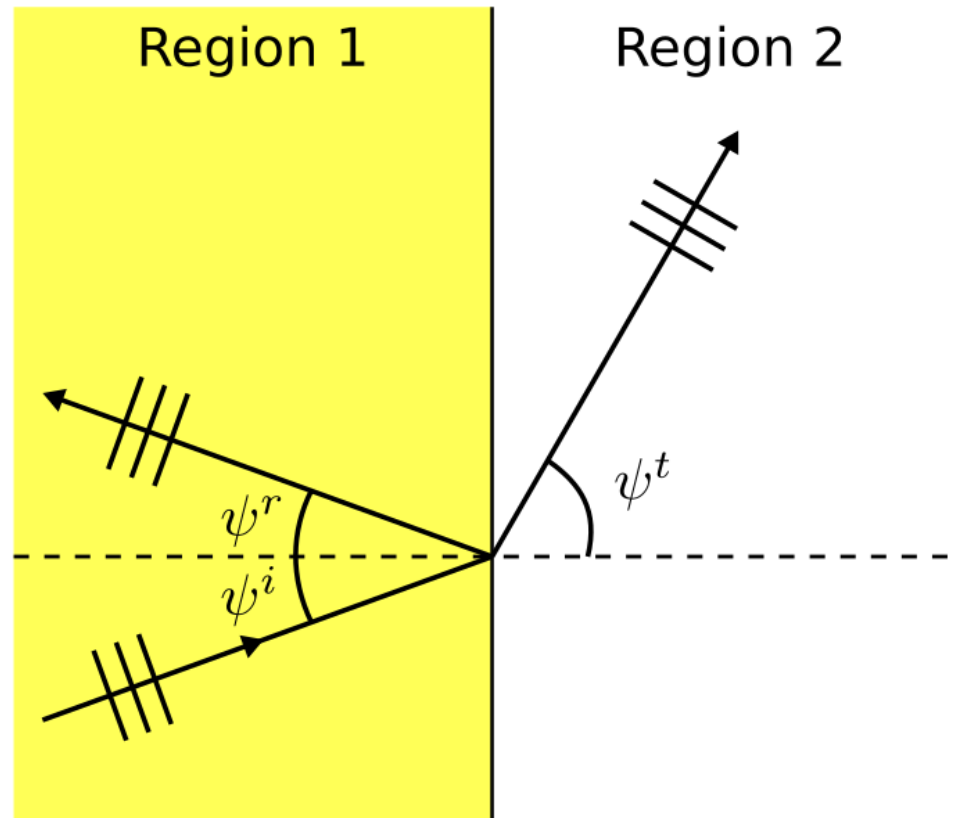


Fig. 5.25: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Upw\\_incident\\_on\\_planar\\_boundary\\_angle\\_reflection\\_equals\\_incidence.svg](https://commons.wikimedia.org/wiki/File:Upw_incident_on_planar_boundary_angle_reflection_equals_incidence.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>), modified.

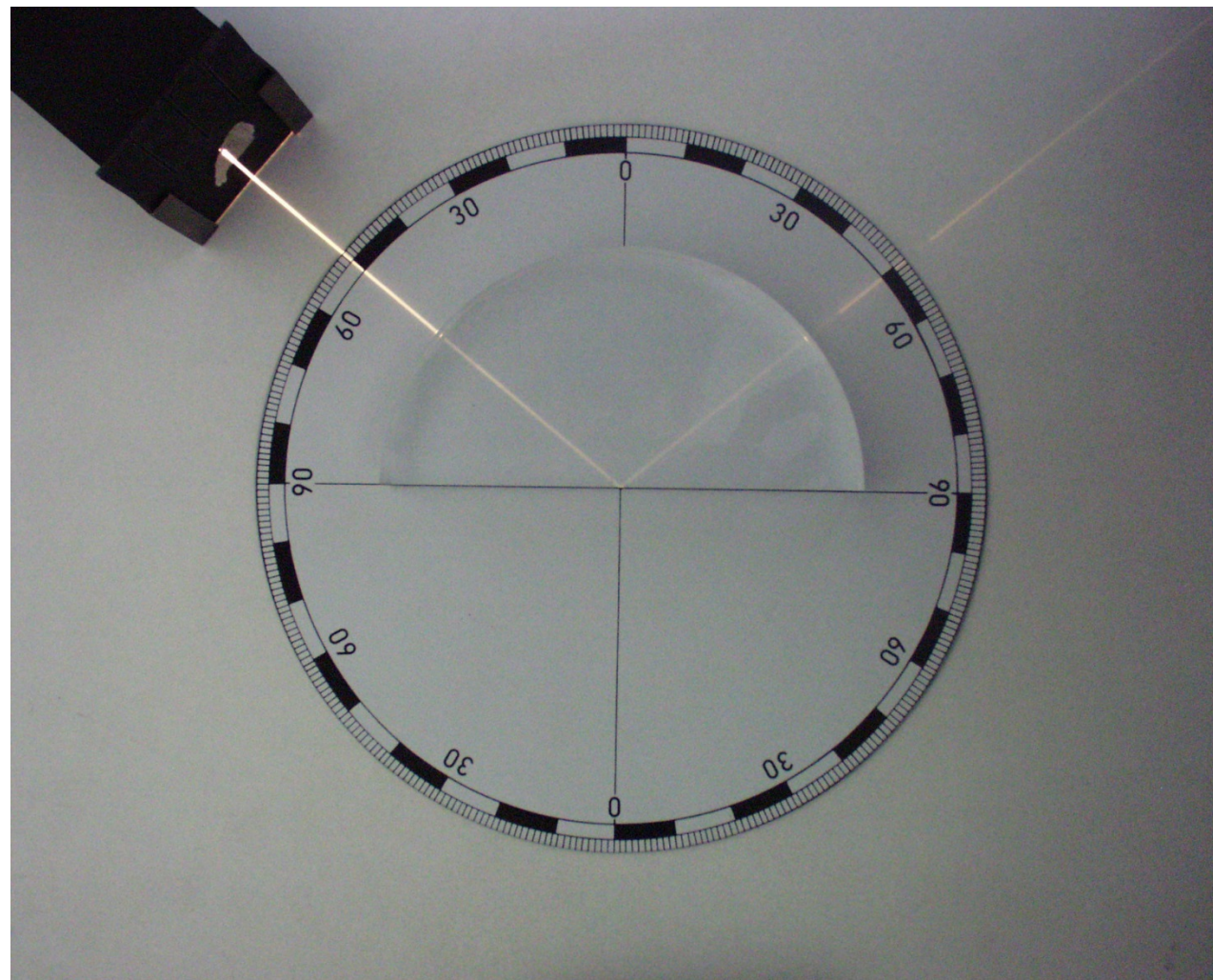


Fig. 5.26: © Z. Sándor, [https://en.wikipedia.org/wiki/File:Teljes\\_f%C3%A9nyvisszaver%C5%91d%C3%A9s.jpg](https://en.wikipedia.org/wiki/File:Teljes_f%C3%A9nyvisszaver%C5%91d%C3%A9s.jpg), CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/>).

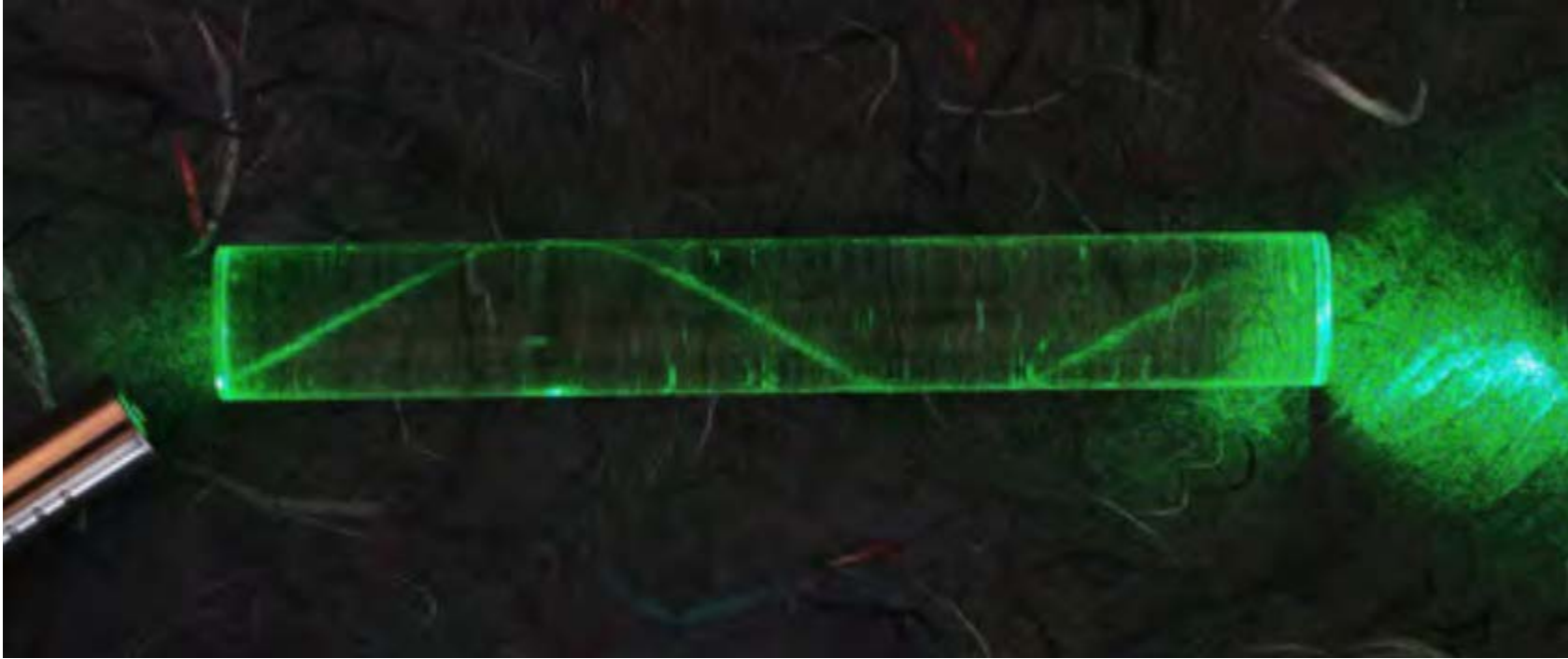


Fig. 5.27: © Timwether, [https://en.wikipedia.org/wiki/File:Laser\\_in\\_fibre.jpg](https://en.wikipedia.org/wiki/File:Laser_in_fibre.jpg), CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/>)

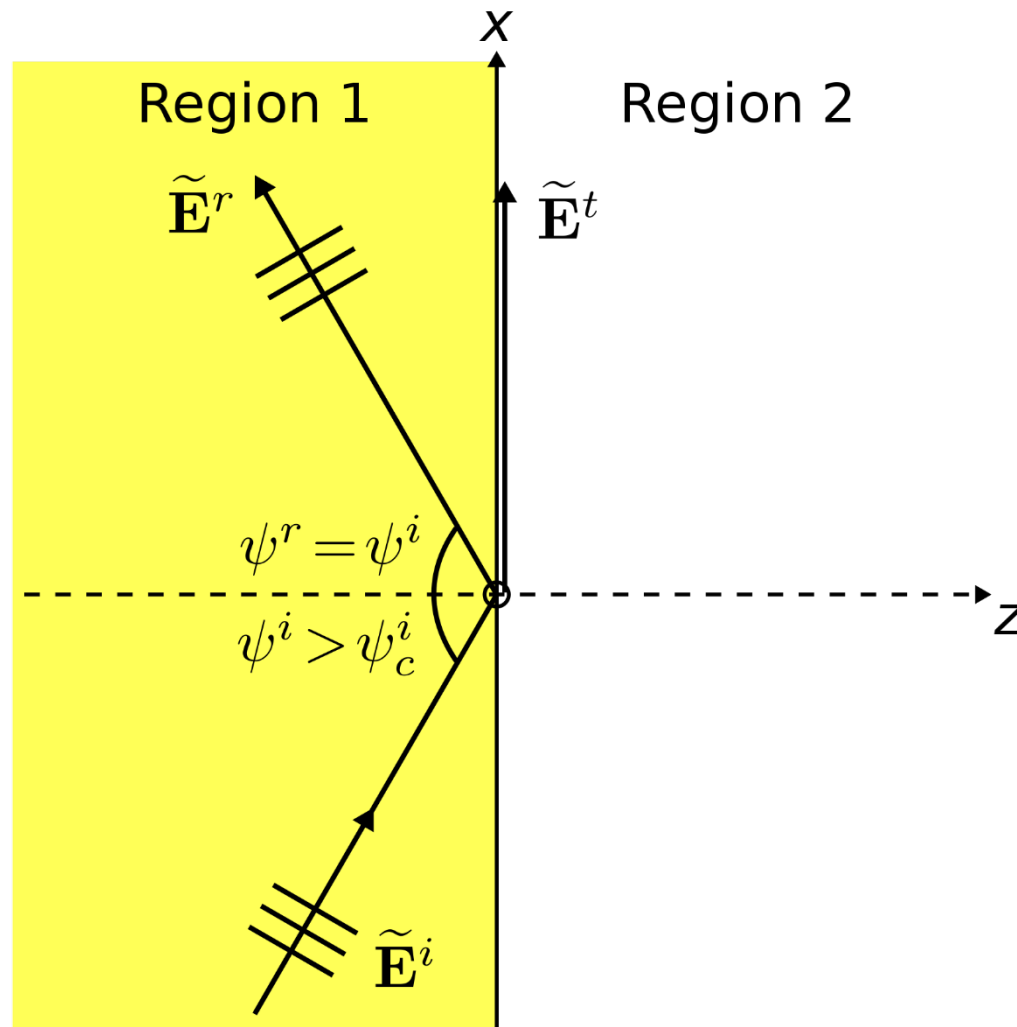


Fig. 5.28: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Upw\\_incident\\_on\\_planar\\_boundary\\_total\\_internal\\_reflection.svg](https://commons.wikimedia.org/wiki/File:Upw_incident_on_planar_boundary_total_internal_reflection.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

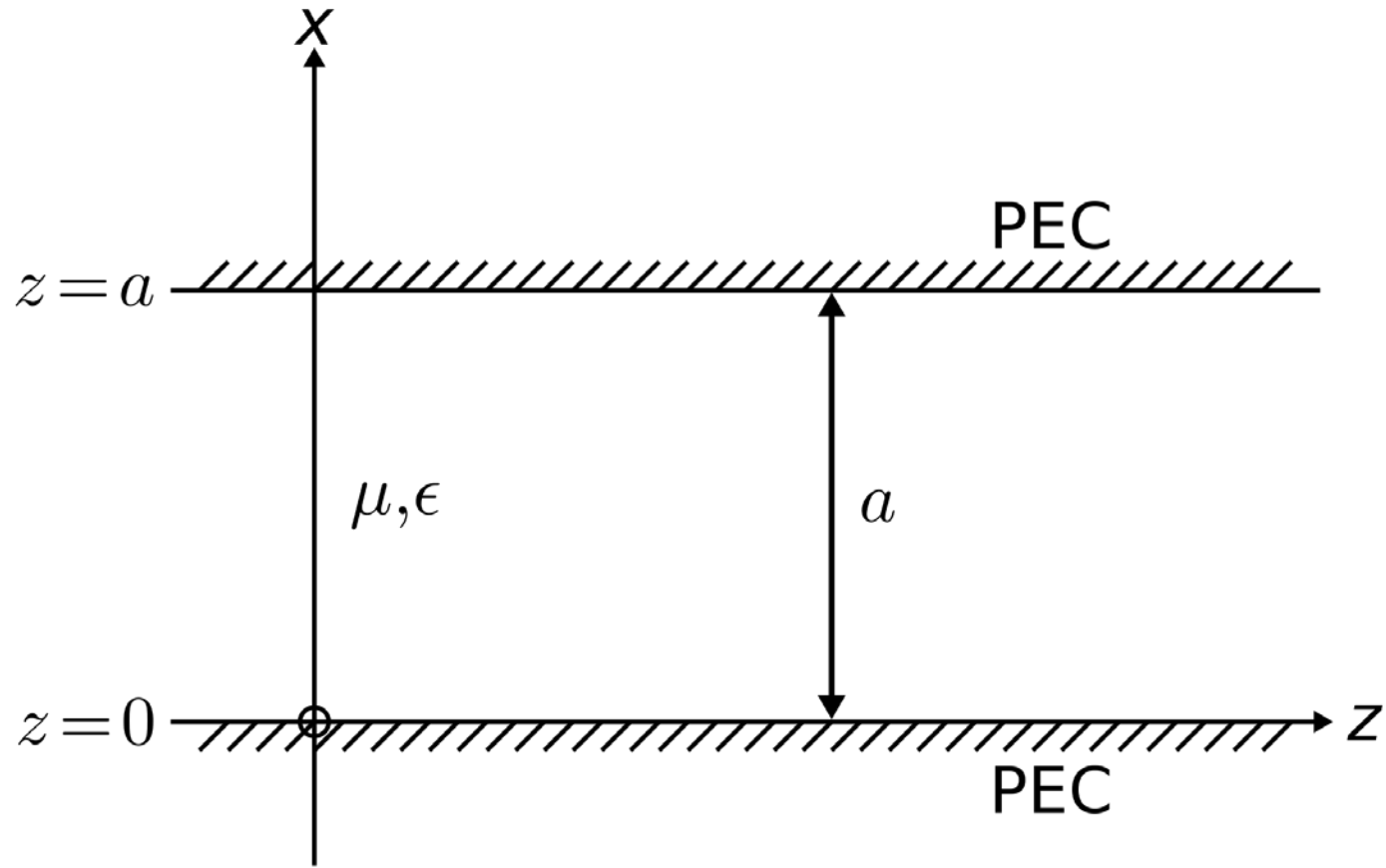


Fig. 6.1: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Geometry\\_for\\_analysis\\_of\\_fields\\_in\\_parallel\\_plate\\_waveguide.svg](https://commons.wikimedia.org/wiki/File:Geometry_for_analysis_of_fields_in_parallel_plate_waveguide.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

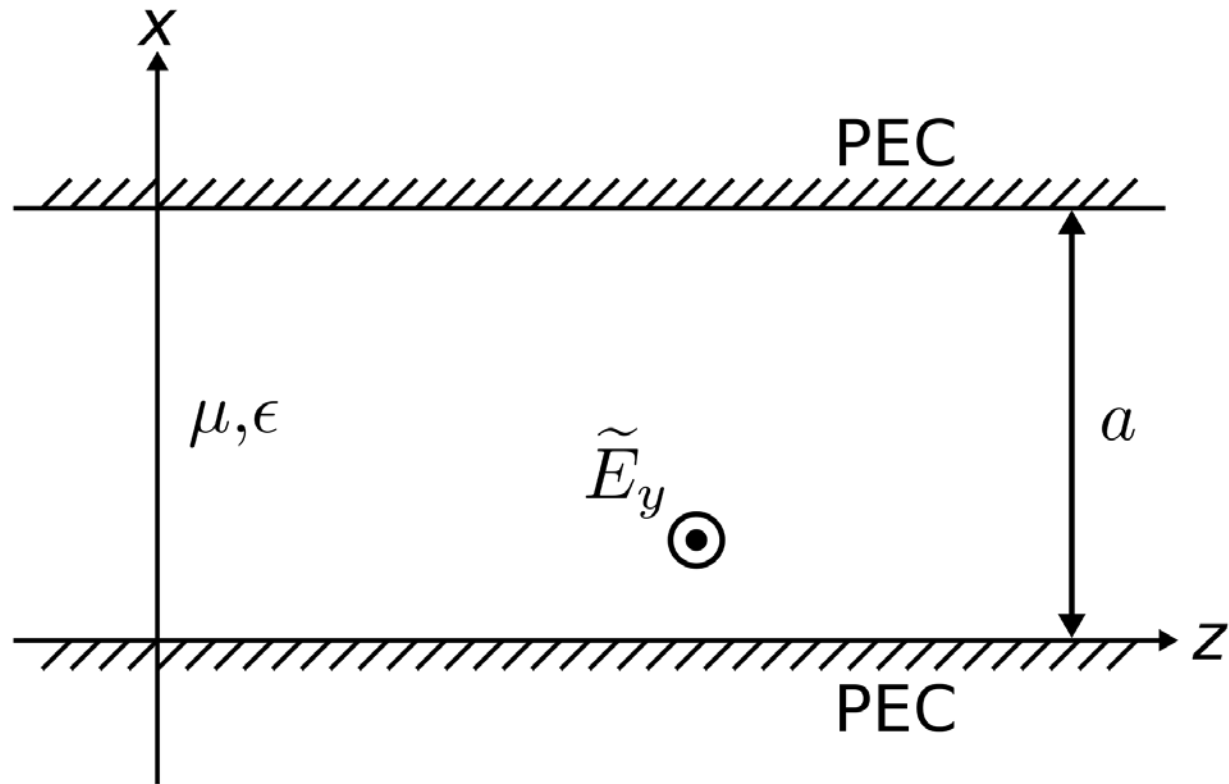


Fig. 6.2: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:TE component of electric field in parallel plate waveguide.svg](https://commons.wikimedia.org/wiki/File:TE_component_of_electric_field_in_parallel_plate_waveguide.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).



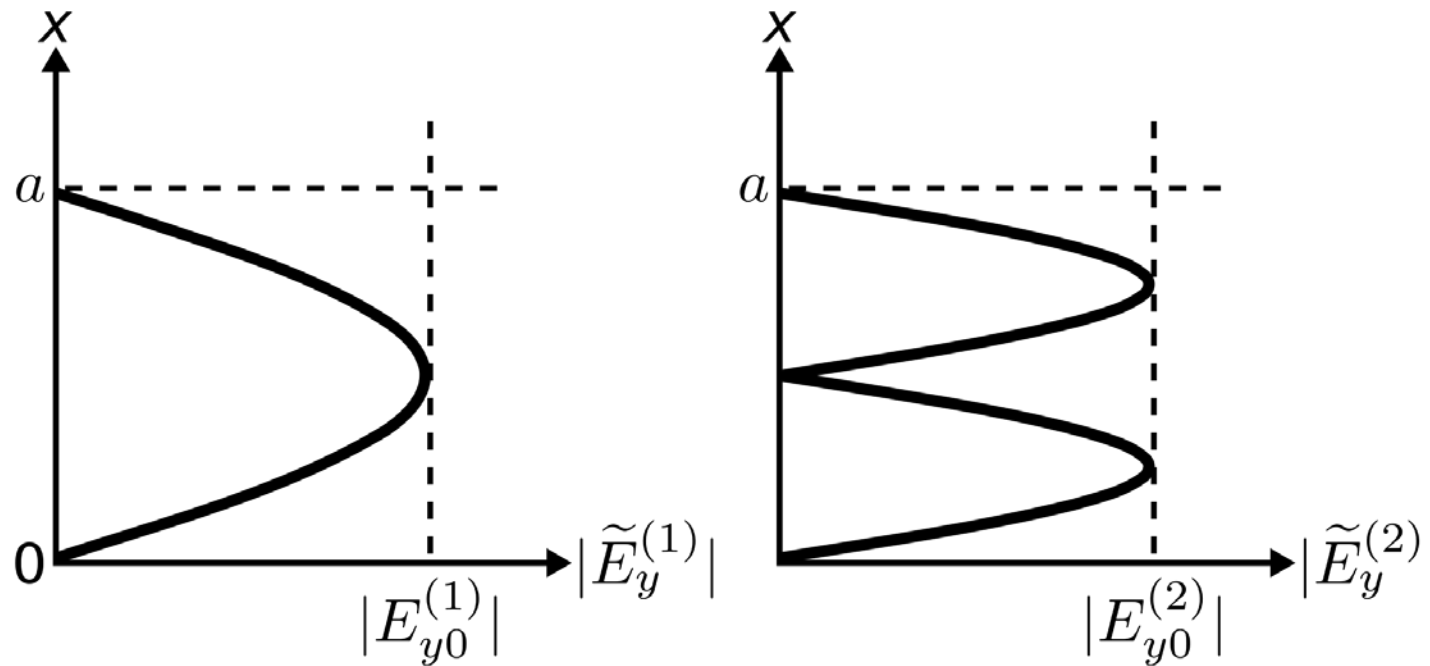


Fig. 6.3: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Magnitude\\_of\\_the\\_two\\_lowest-order\\_TE\\_modes\\_in\\_parallel\\_plate\\_waveguide.svg](https://commons.wikimedia.org/wiki/File:Magnitude_of_the_two_lowest-order_TE_modes_in_parallel_plate_waveguide.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

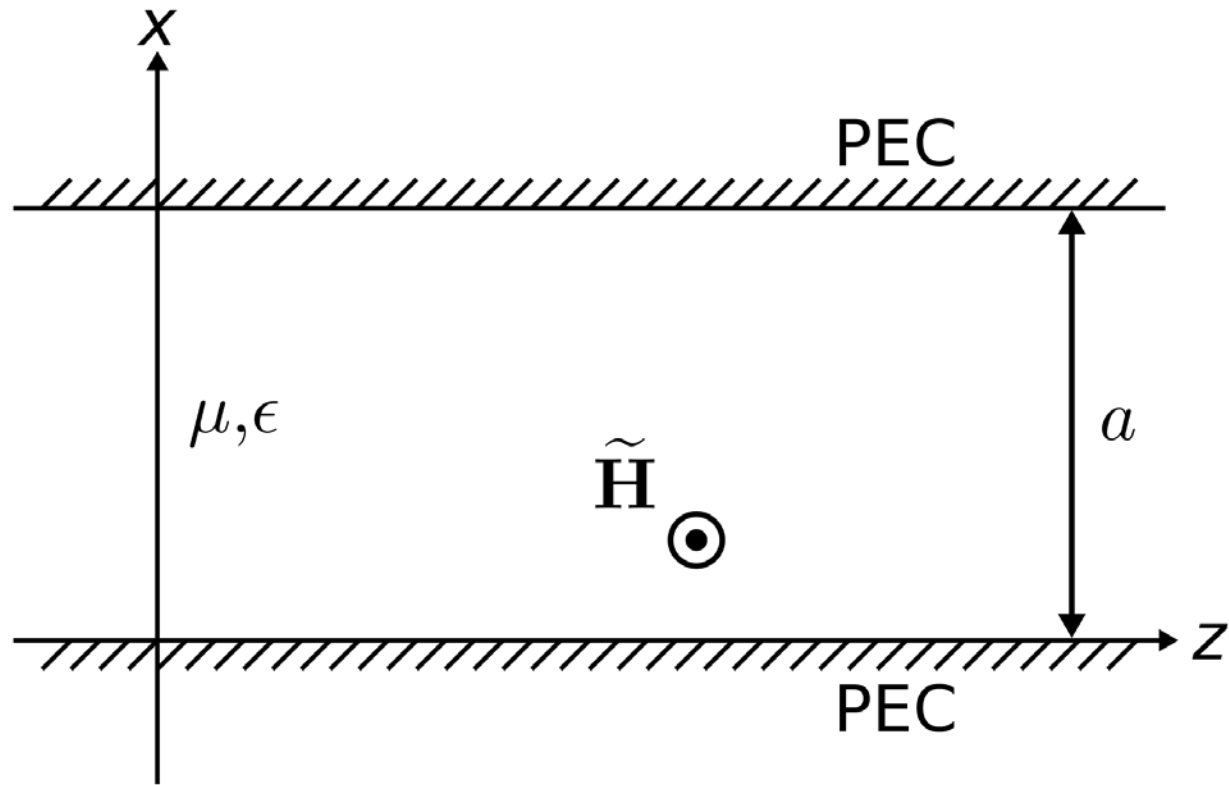


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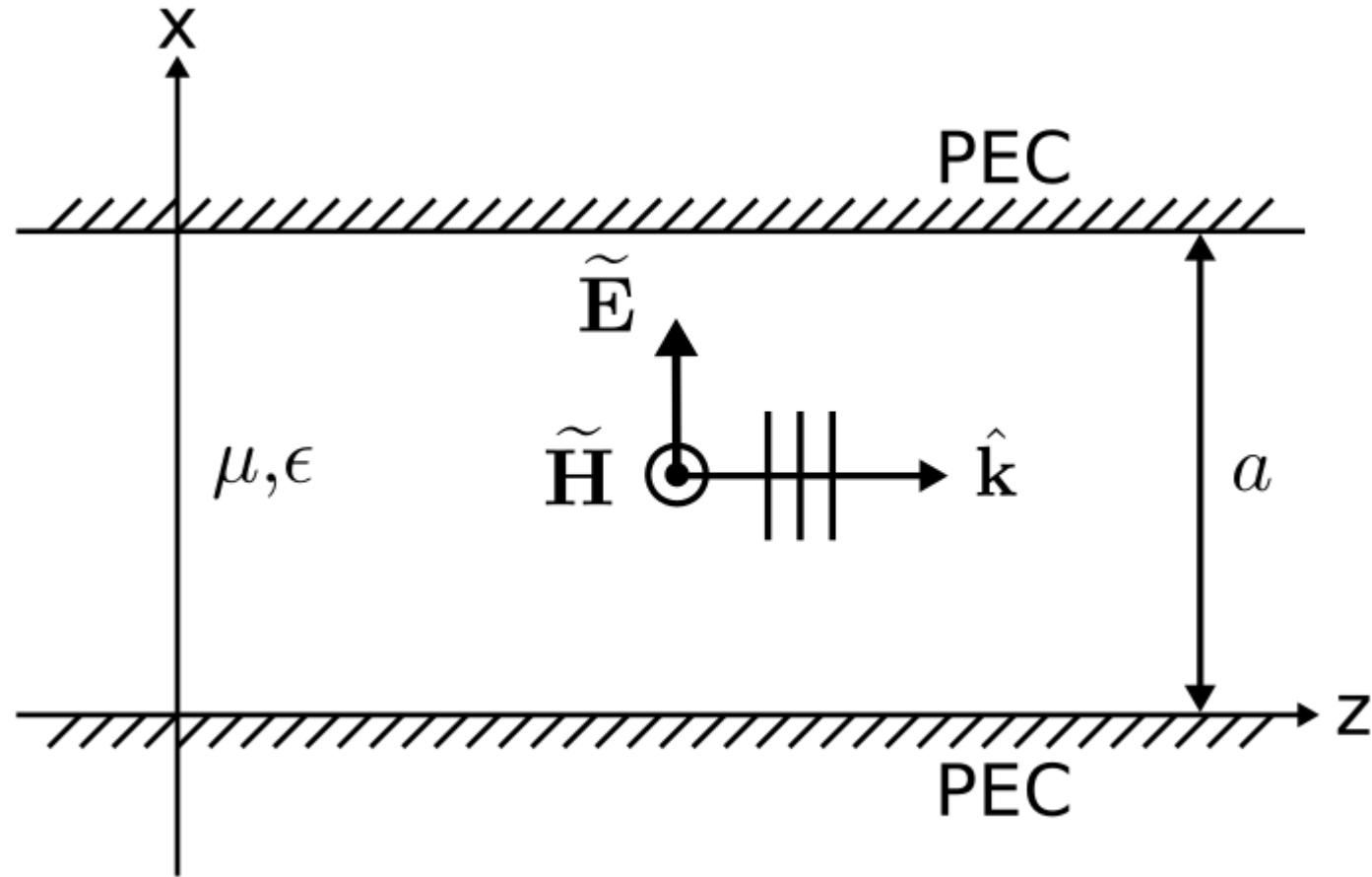


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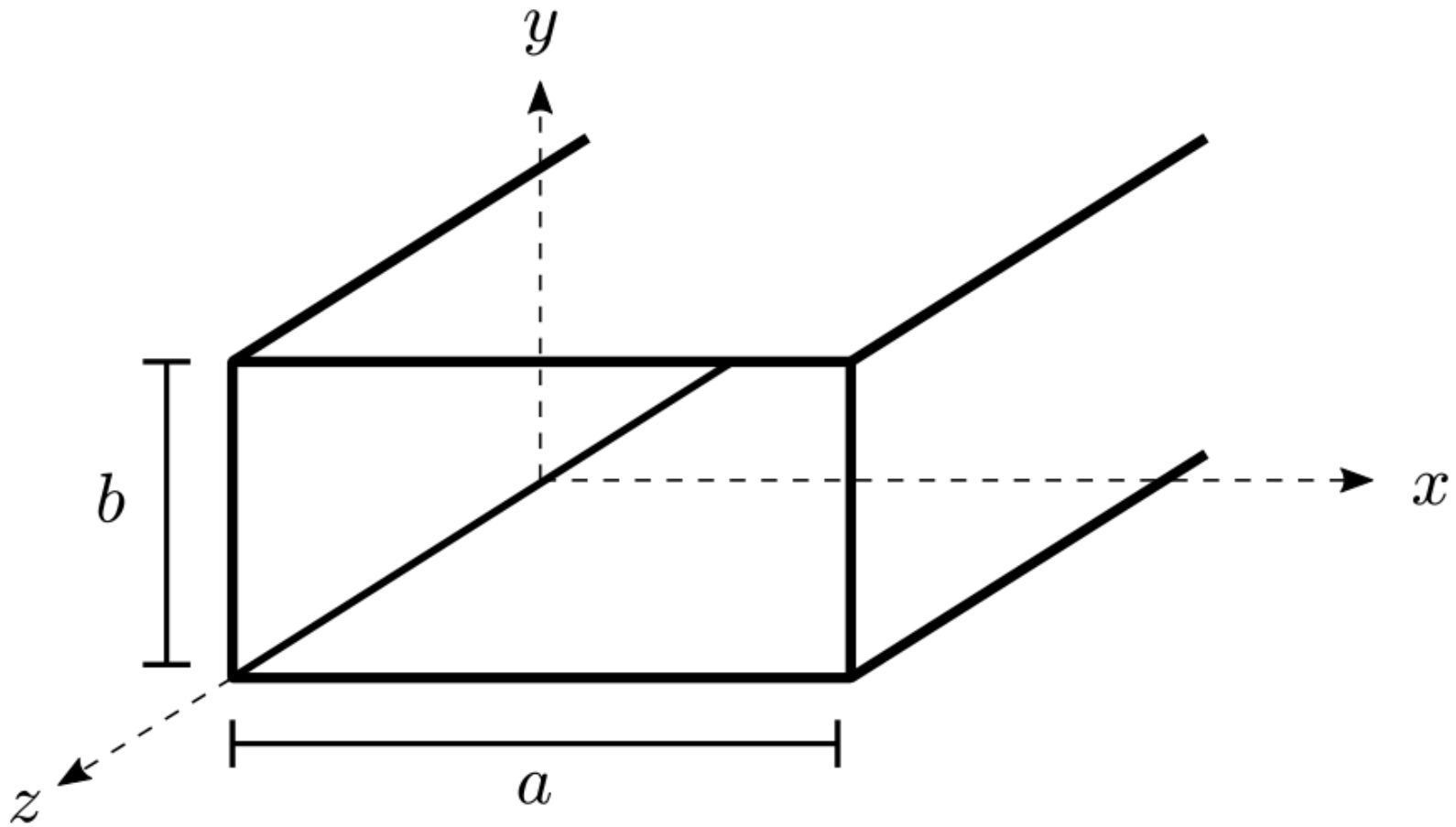


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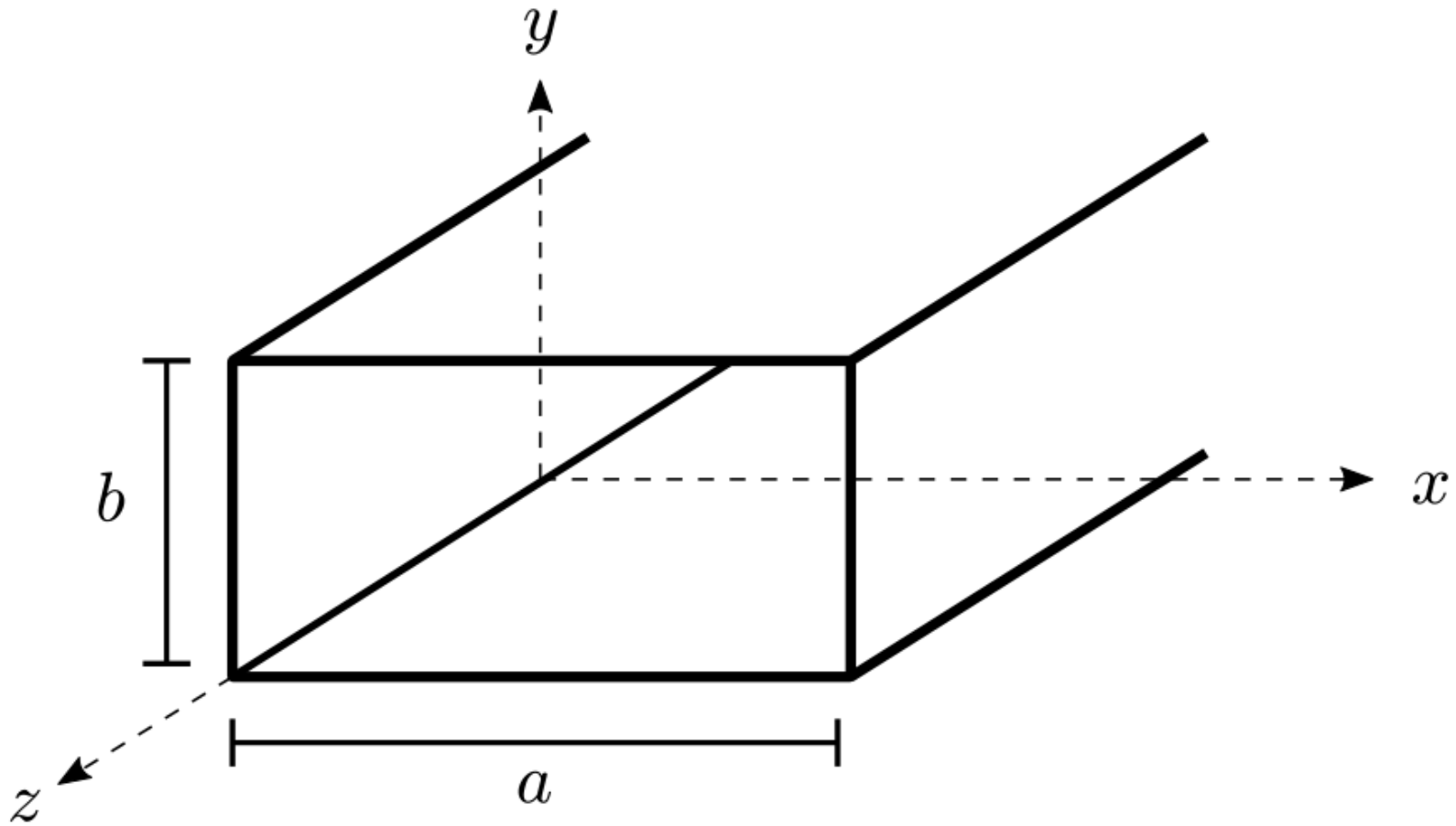


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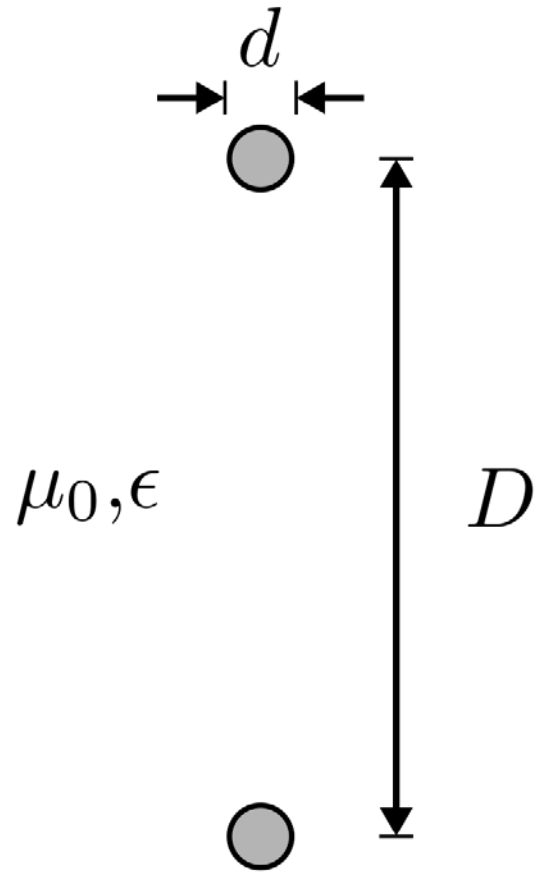


Fig. 7.2: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Parallel wire transmission line structure and design parameters.svg](https://commons.wikimedia.org/wiki/File:Parallel_wire_transmission_line_structure_and_design_parameters.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

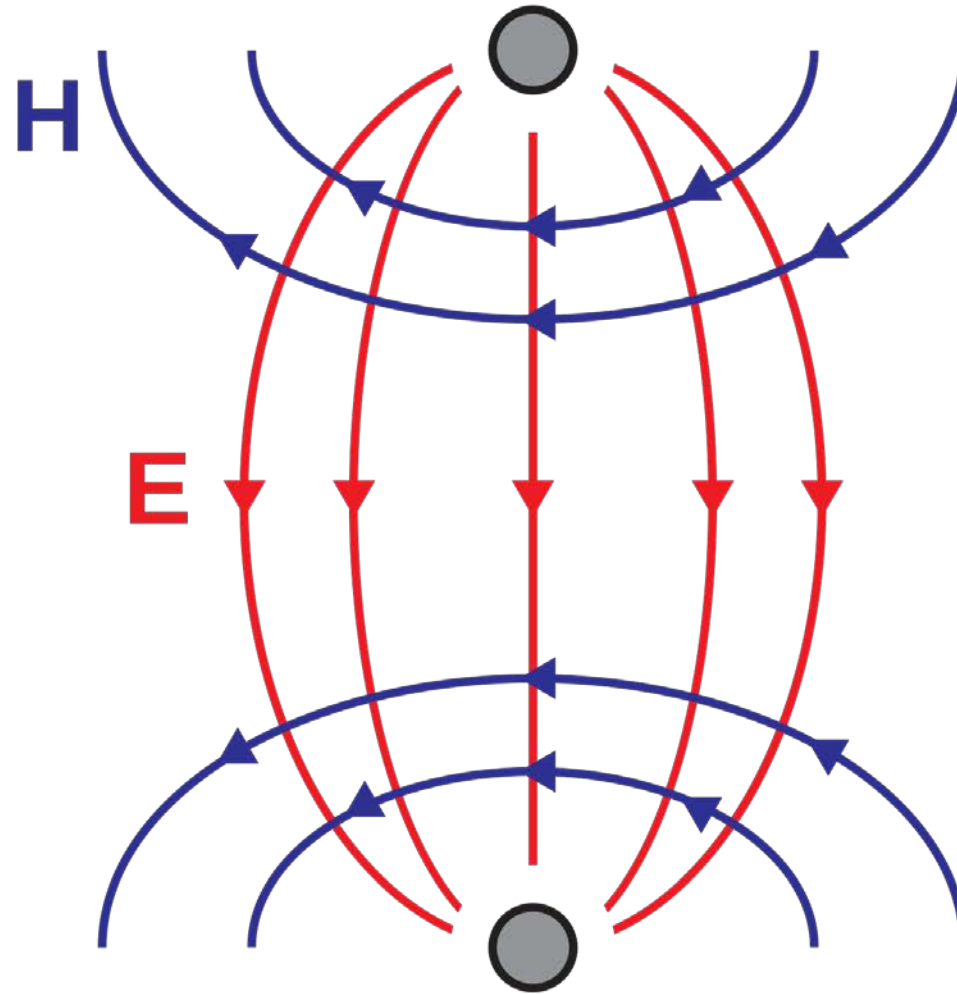


Fig. 7.3: © Offaperry (S. Lally), [https://commons.wikimedia.org/wiki/File:Electric\\_and\\_Magnetic\\_Field\\_of\\_Wire\\_Cross-Section.svg](https://commons.wikimedia.org/wiki/File:Electric_and_Magnetic_Field_of_Wire_Cross-Section.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).



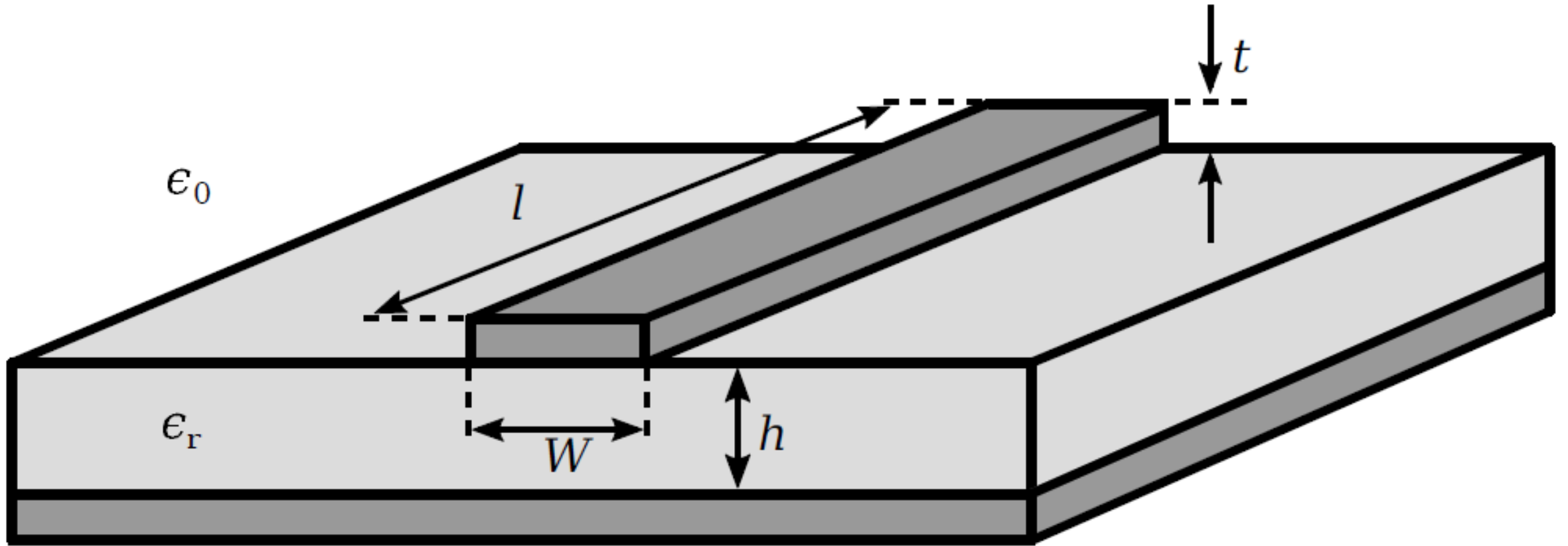


Fig. 7.4: © 7head7metal7, [https://commons.wikimedia.org/wiki/File:Microstrip\\_scheme.svg](https://commons.wikimedia.org/wiki/File:Microstrip_scheme.svg), CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/>). Minor modifications from the original.

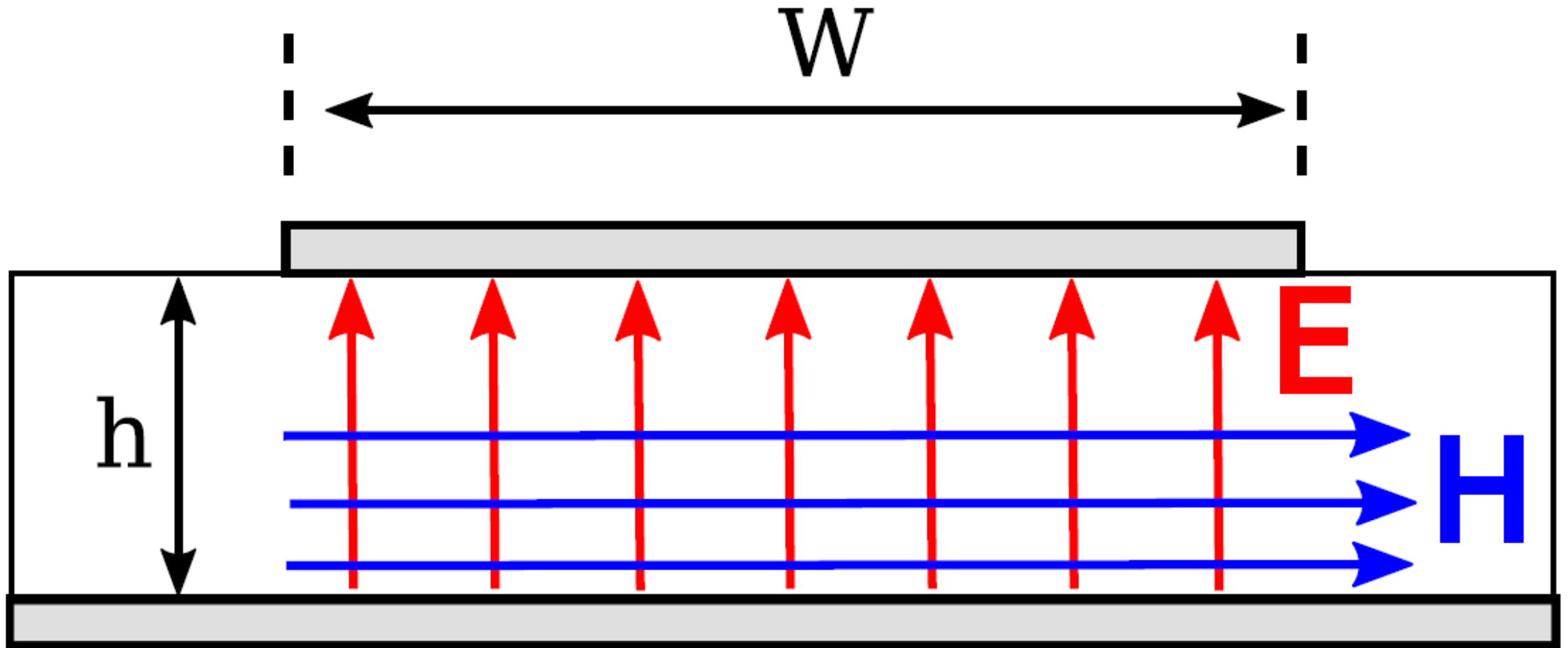


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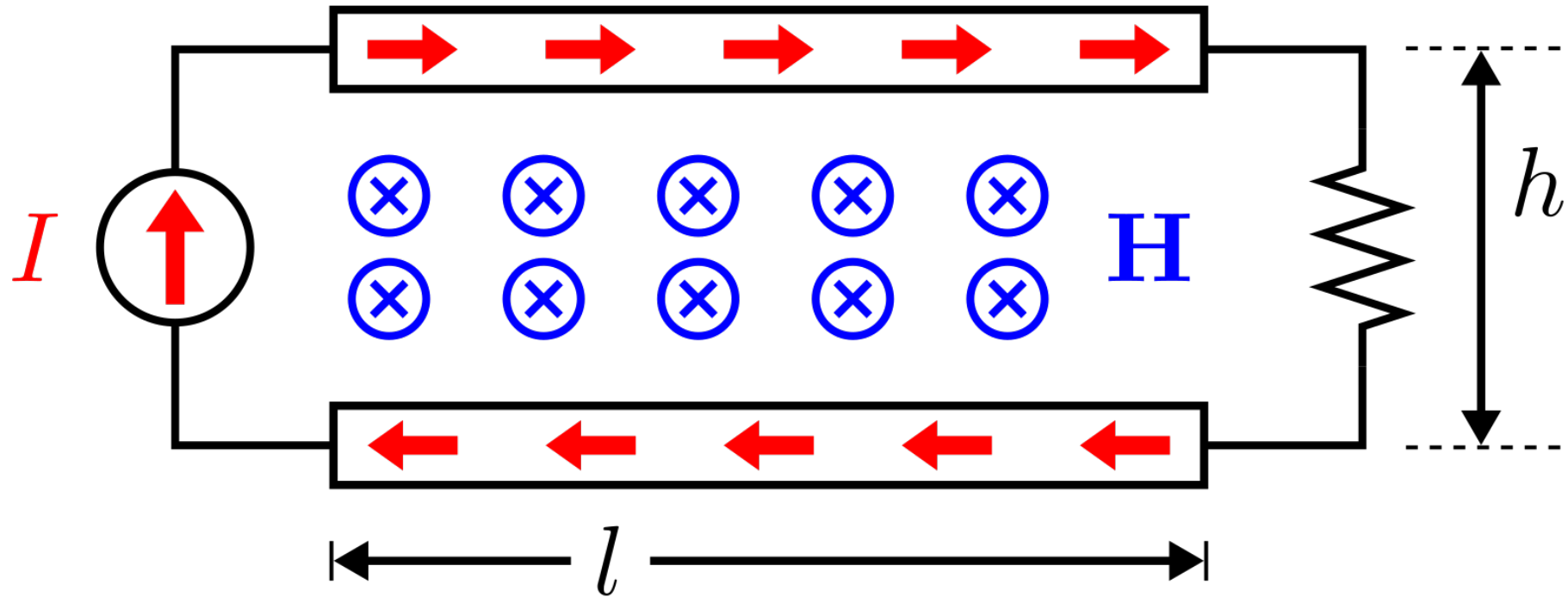


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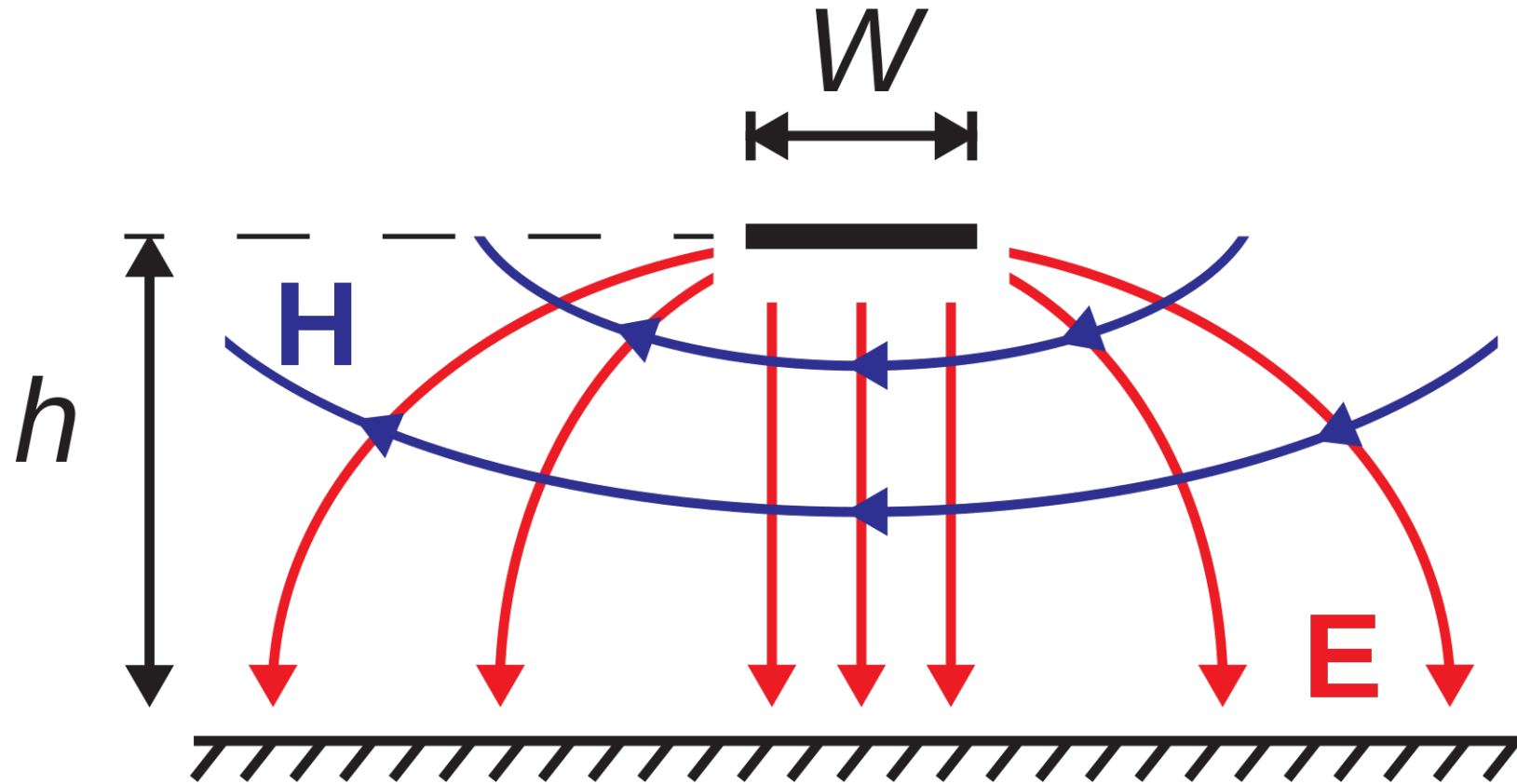


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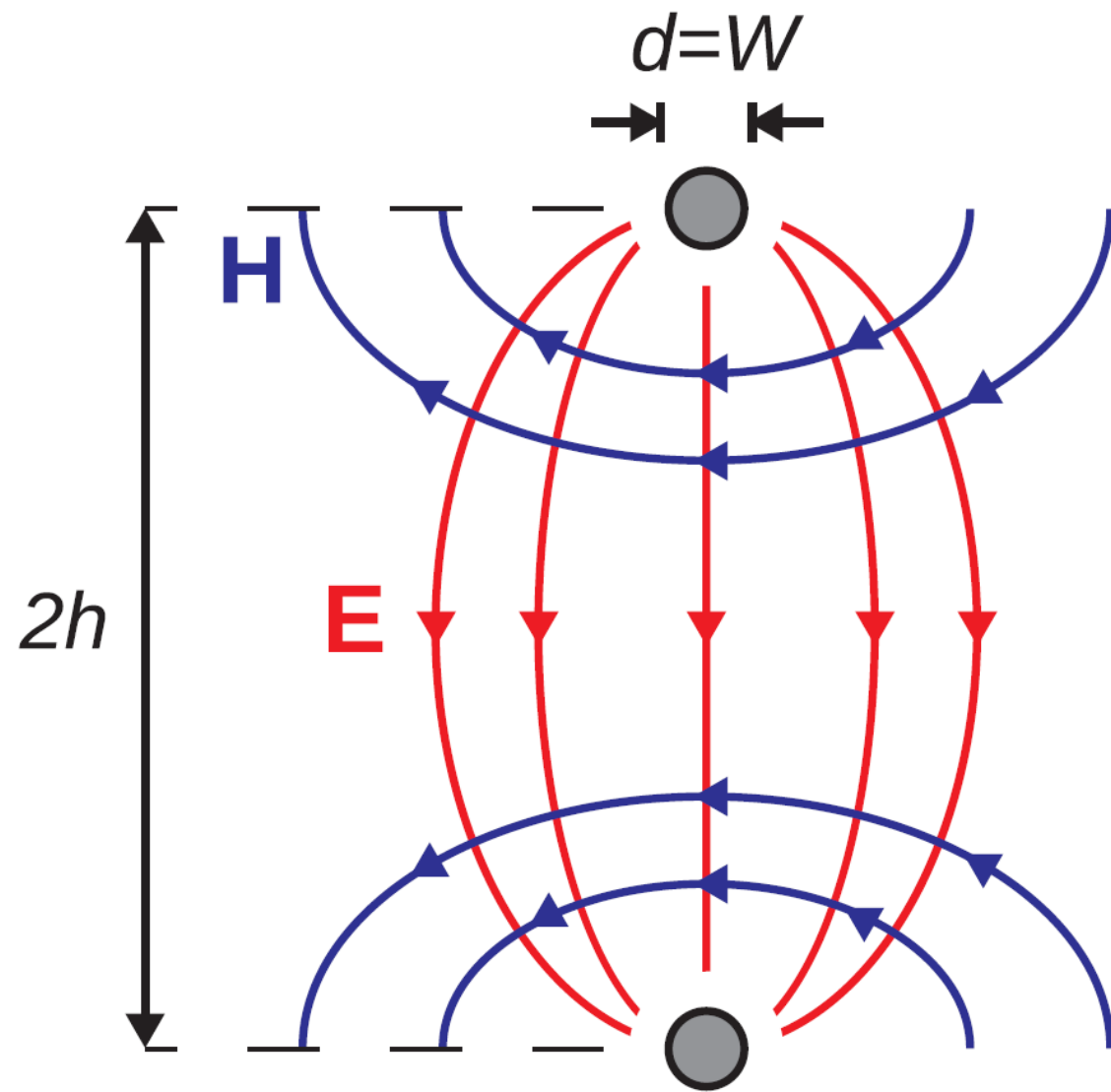


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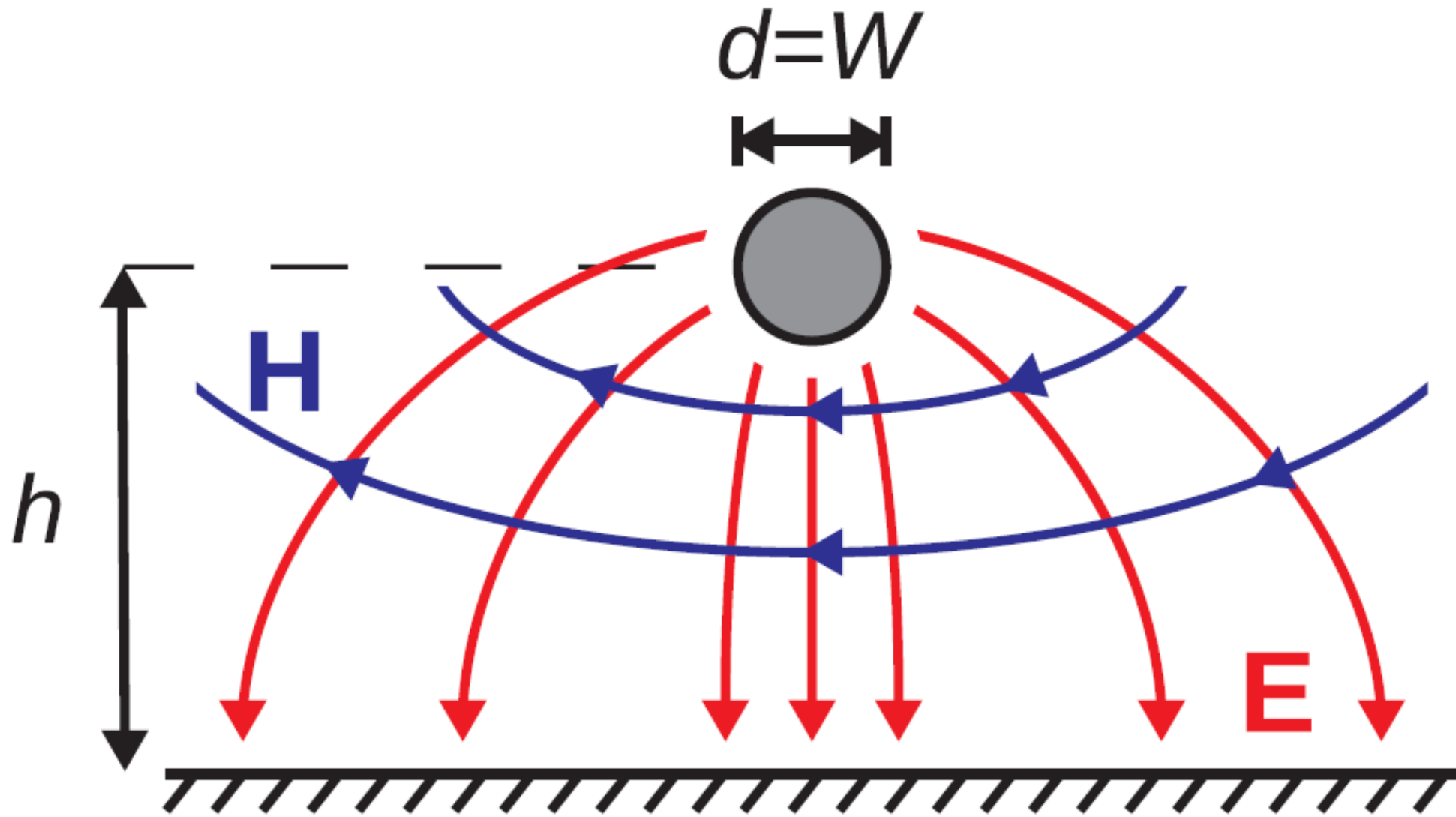


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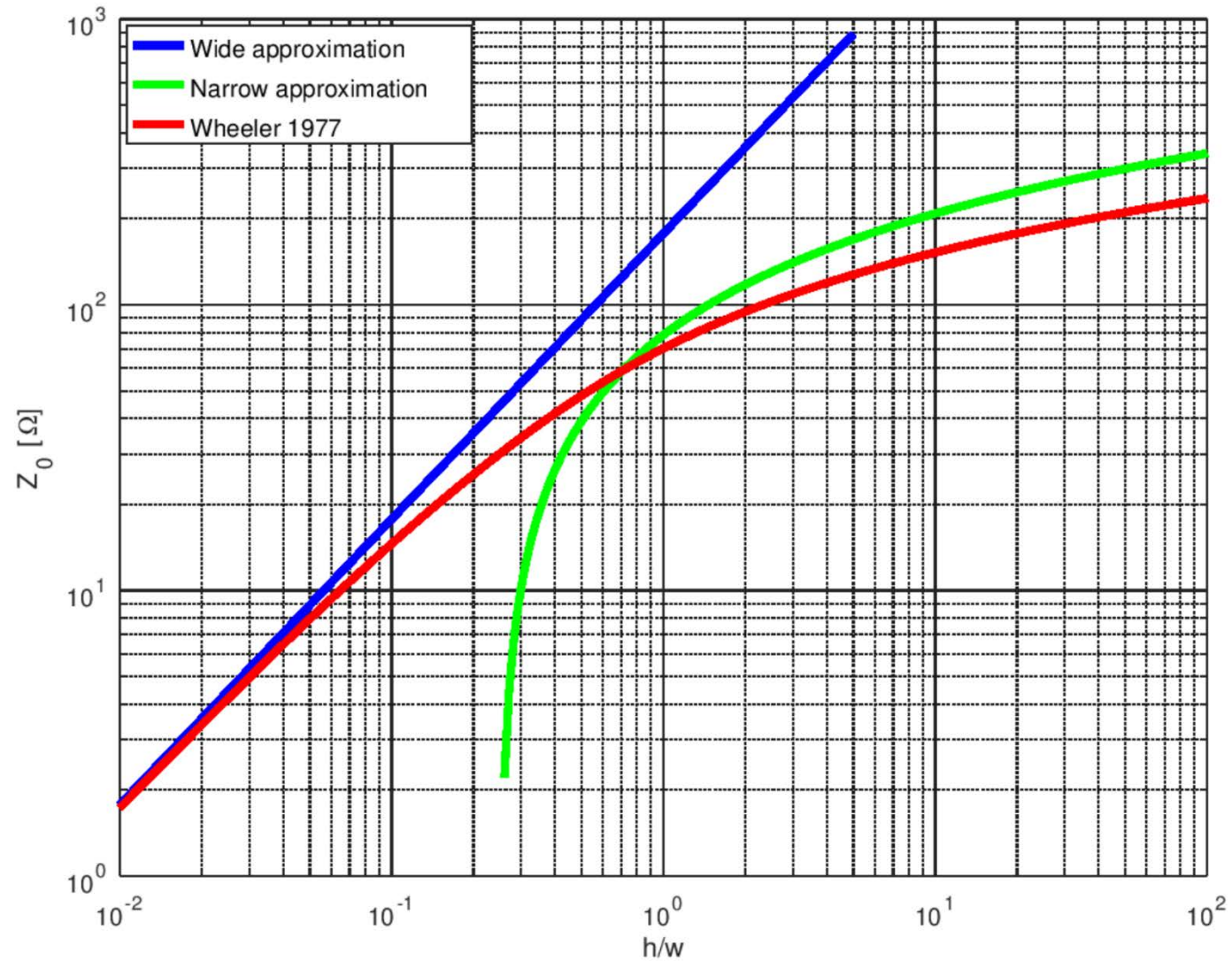


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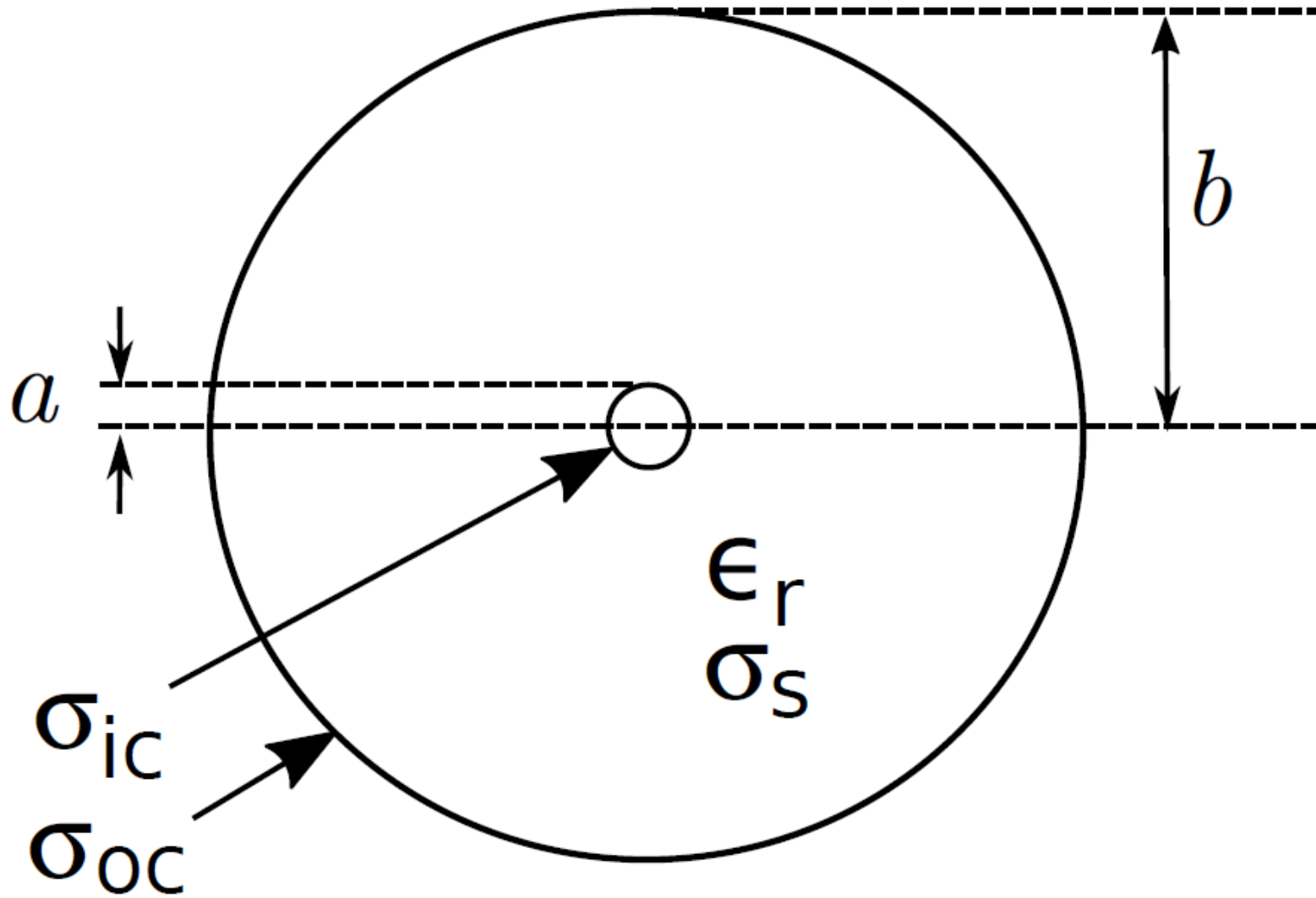


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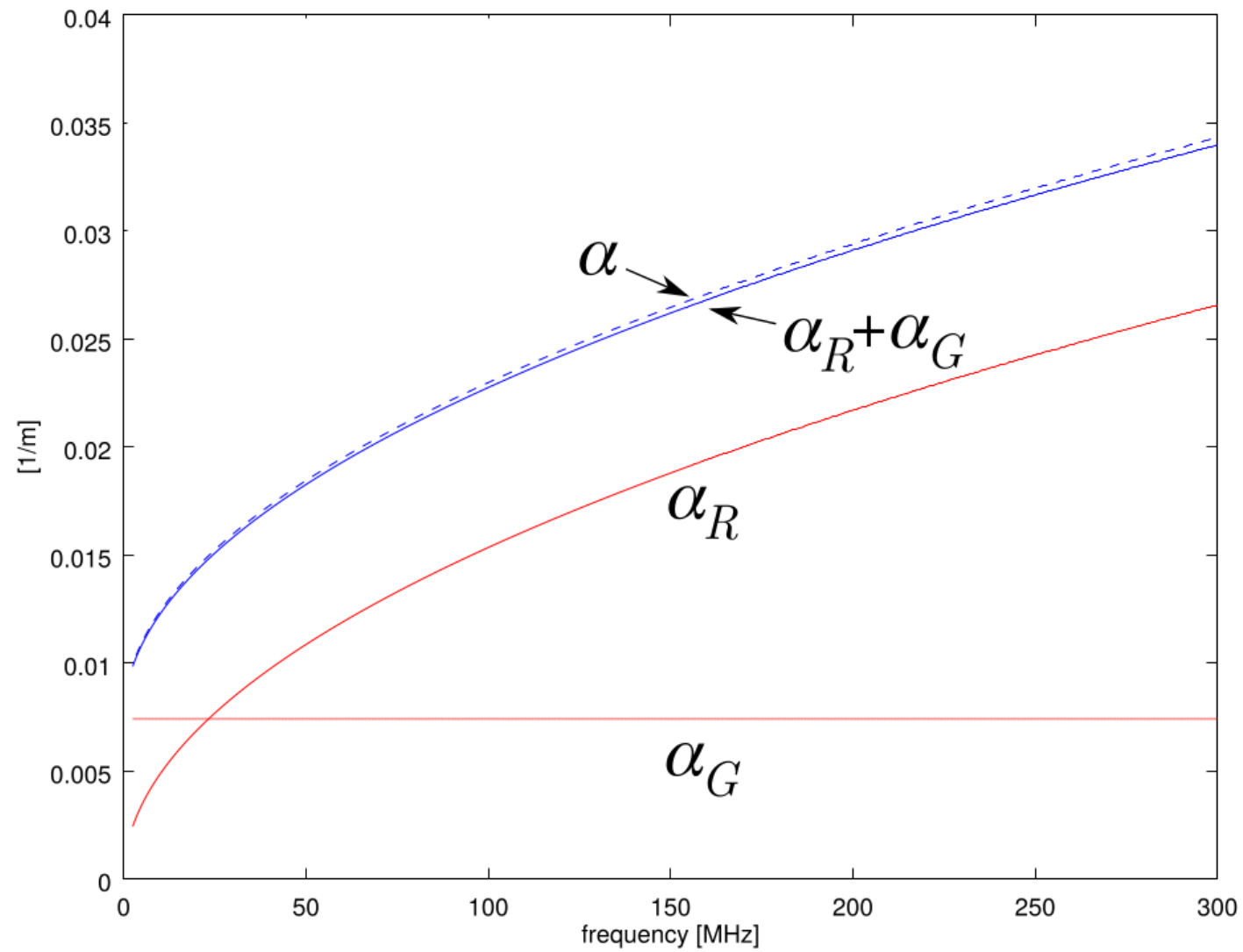


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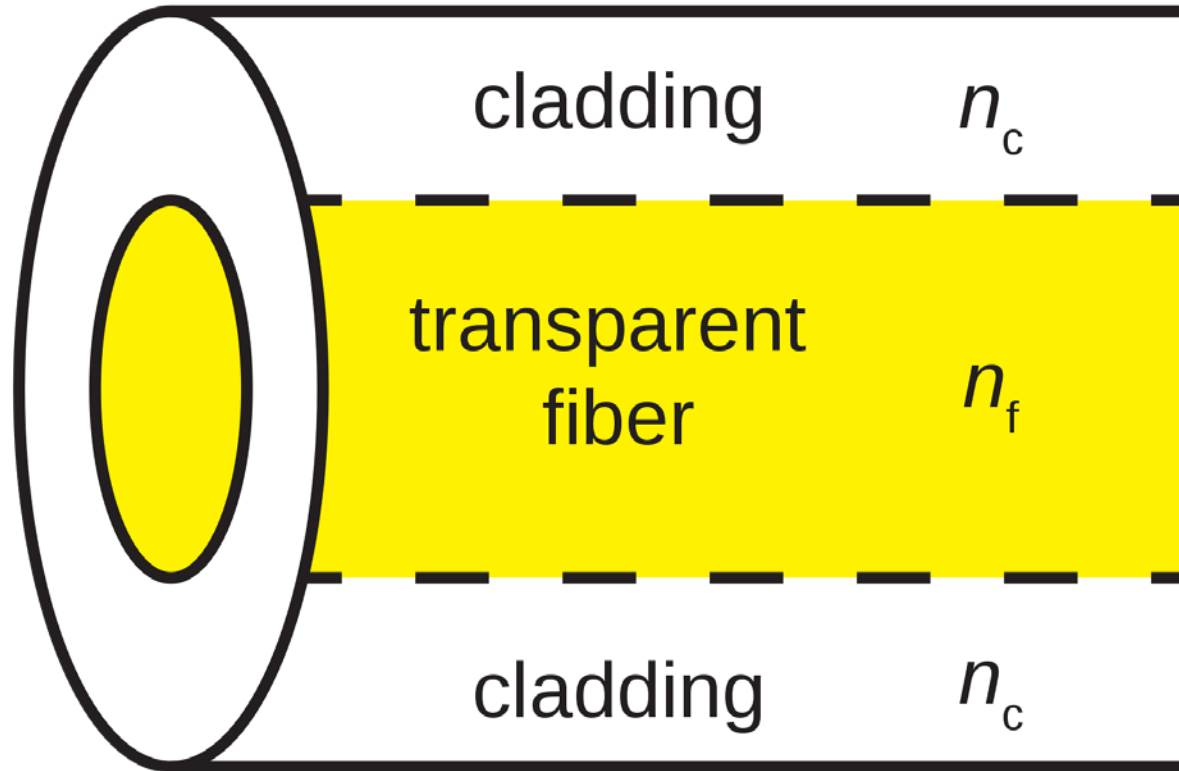


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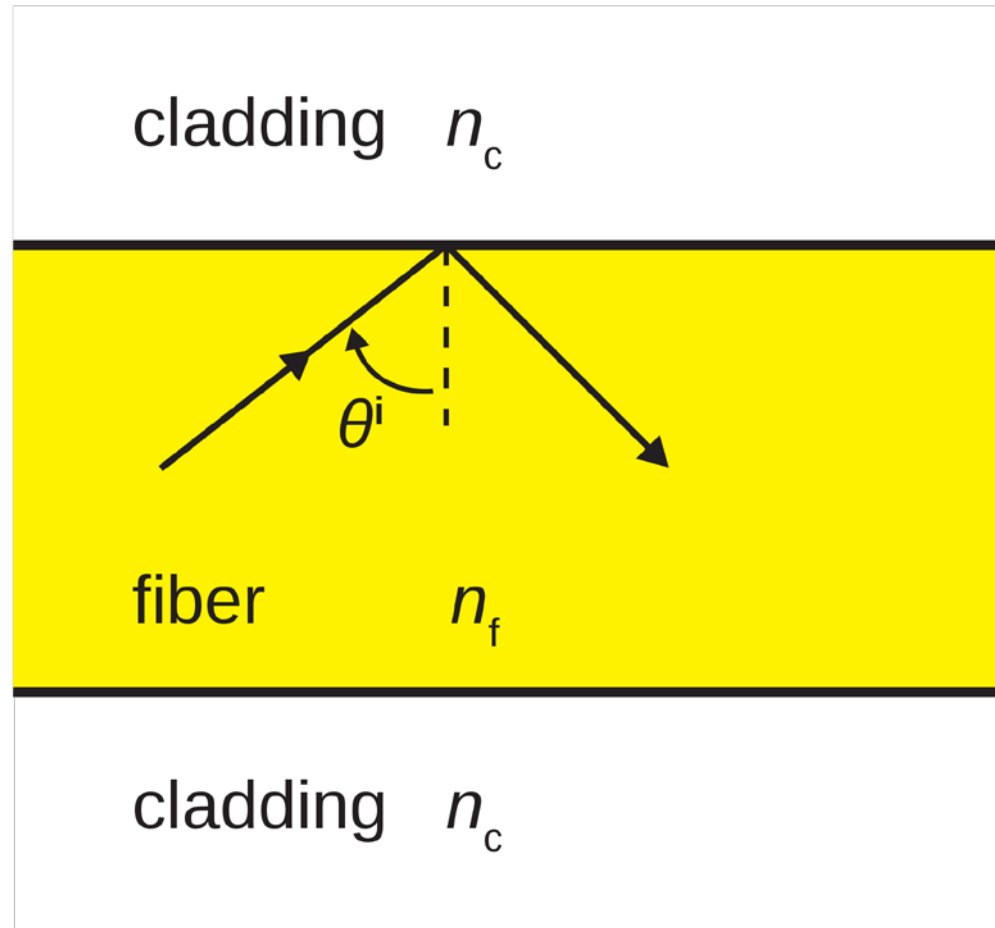


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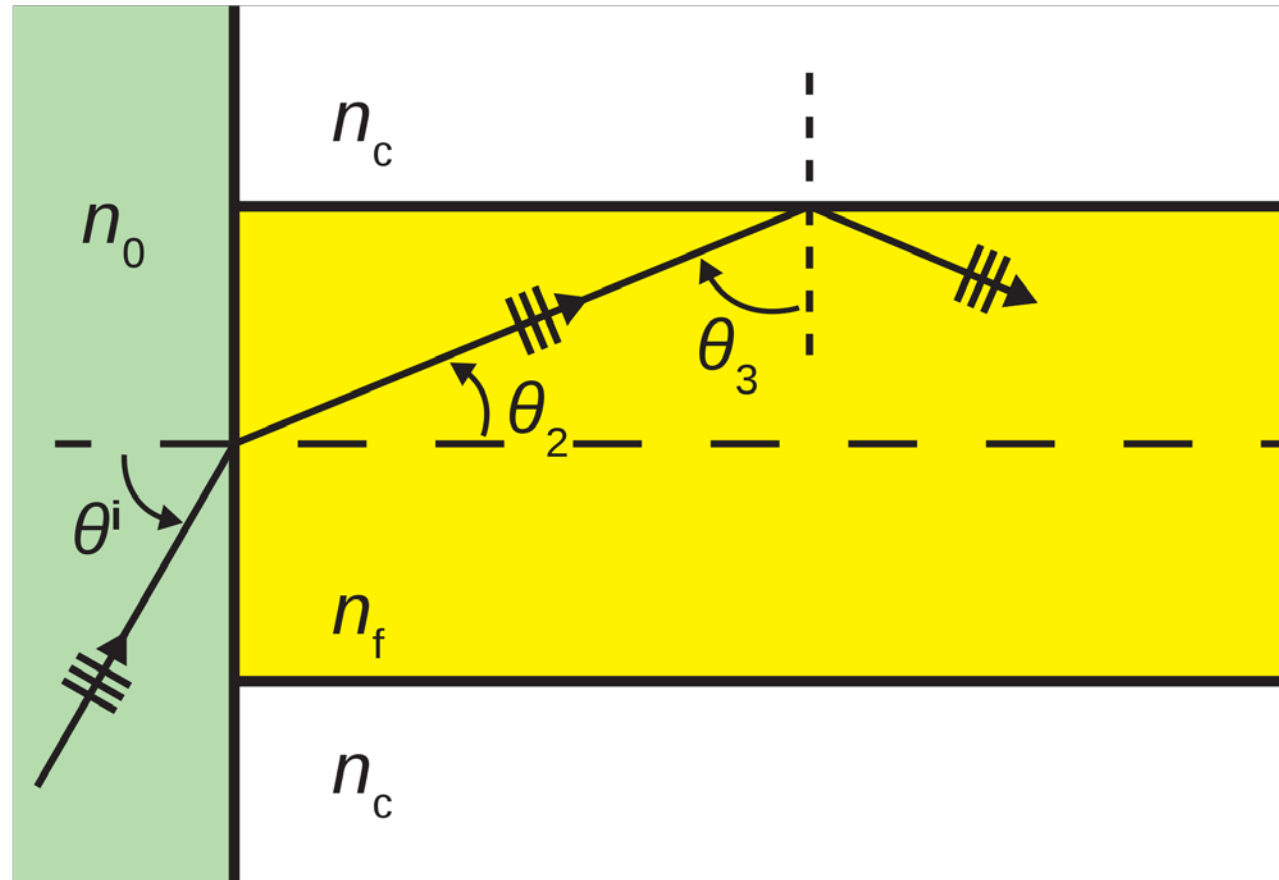


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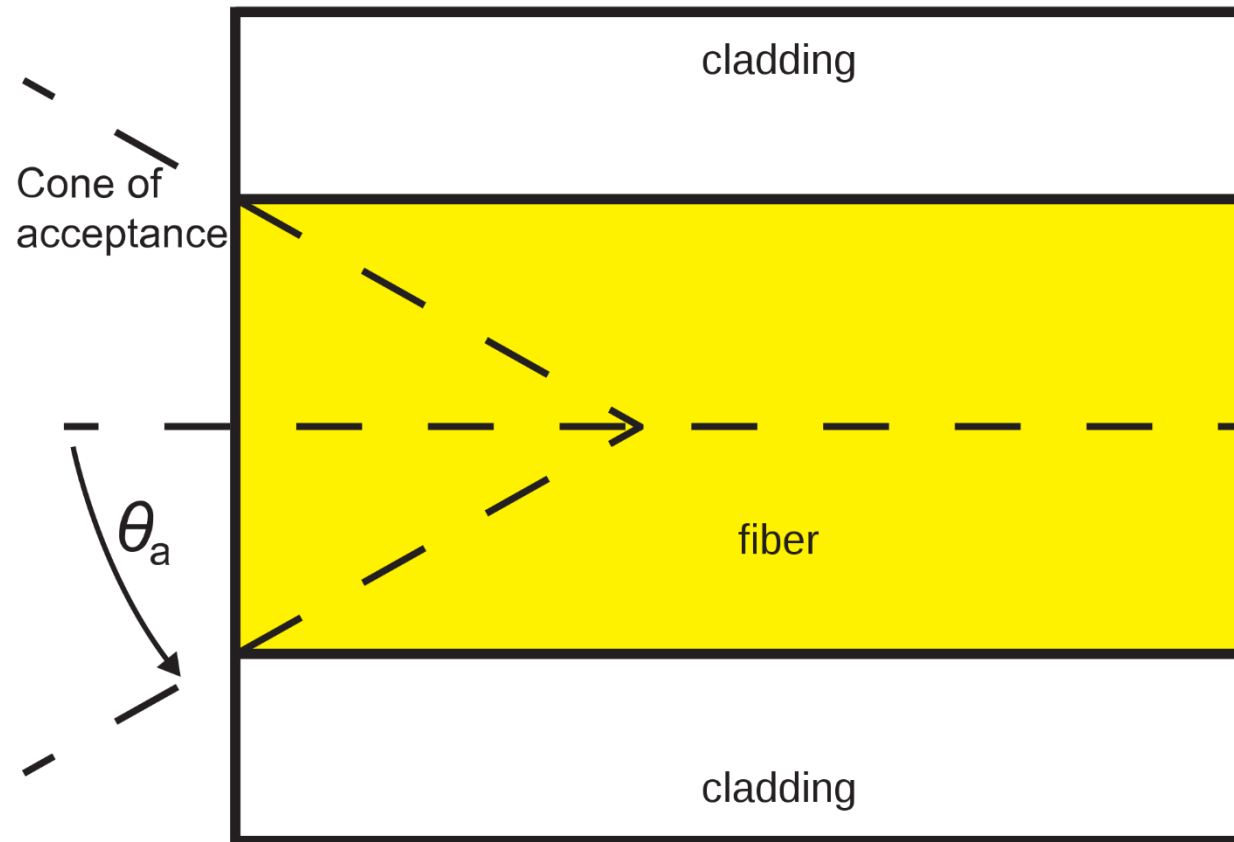


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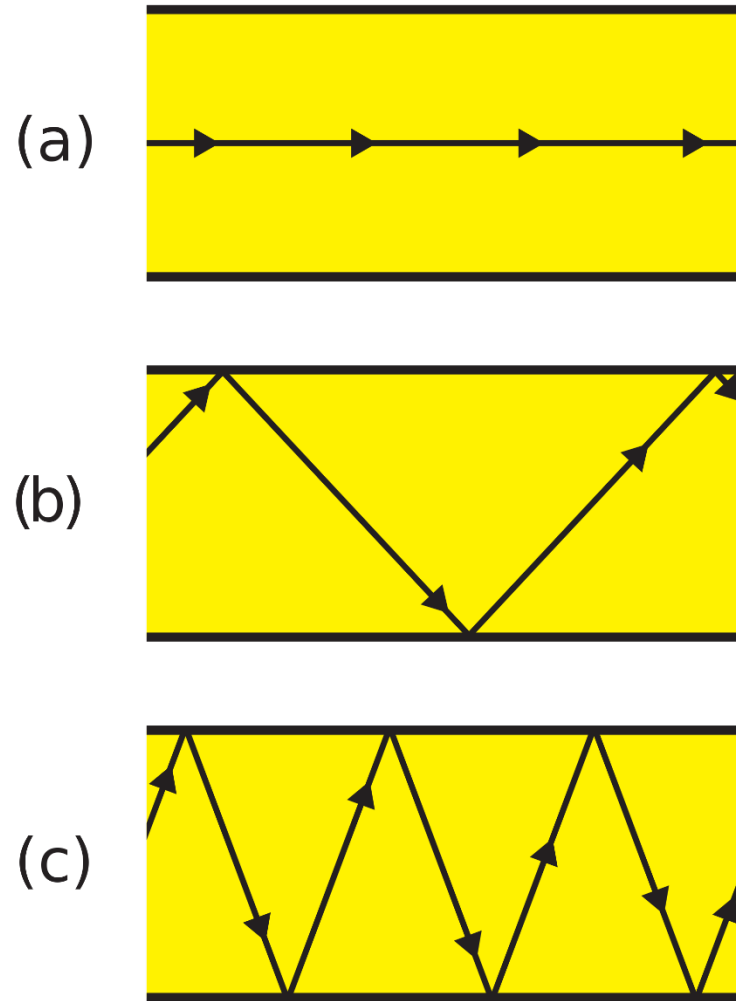


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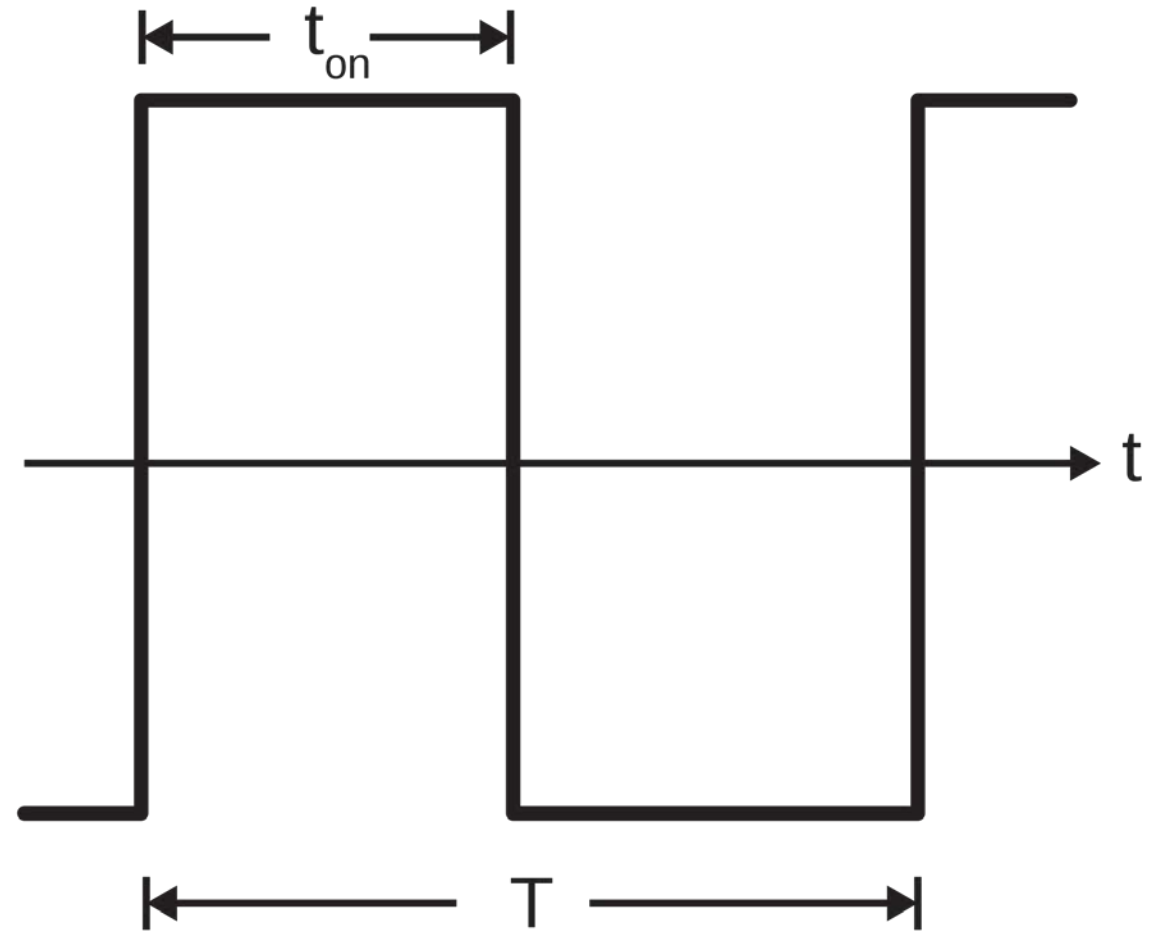


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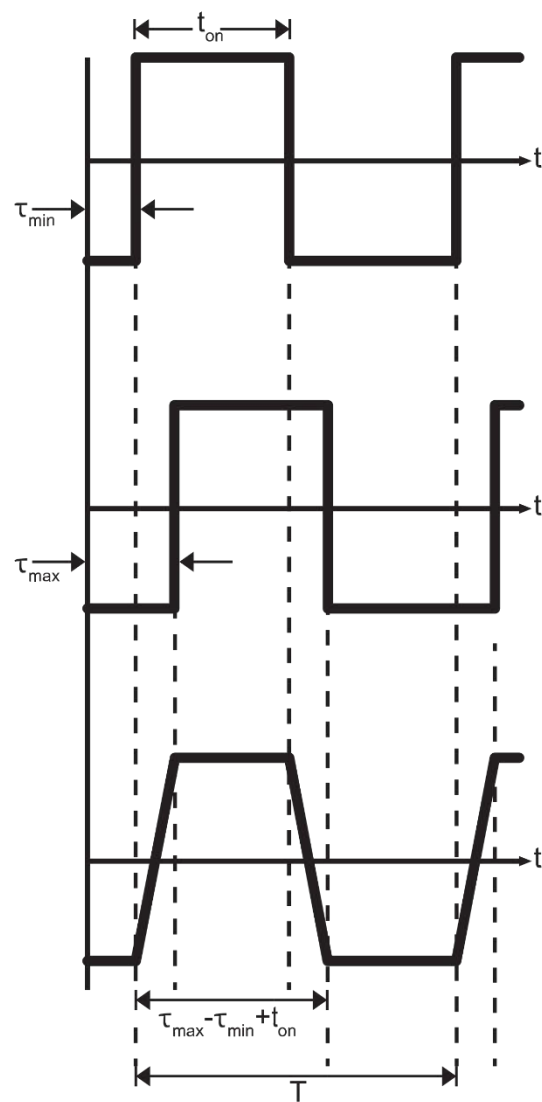


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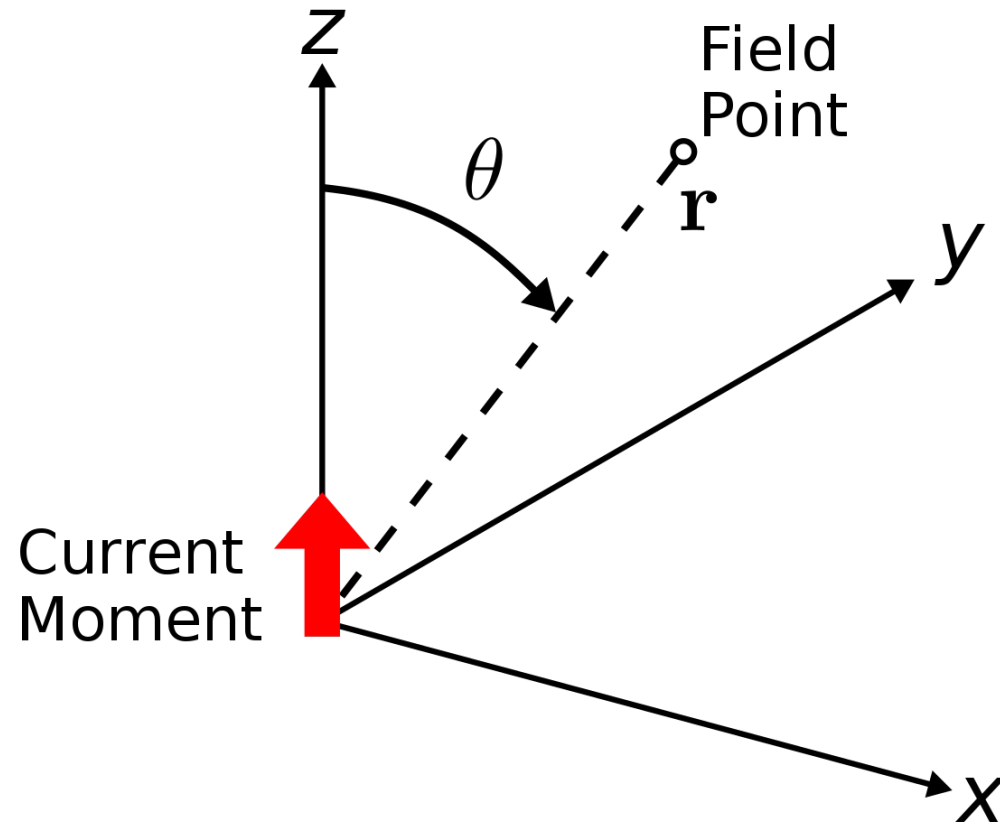


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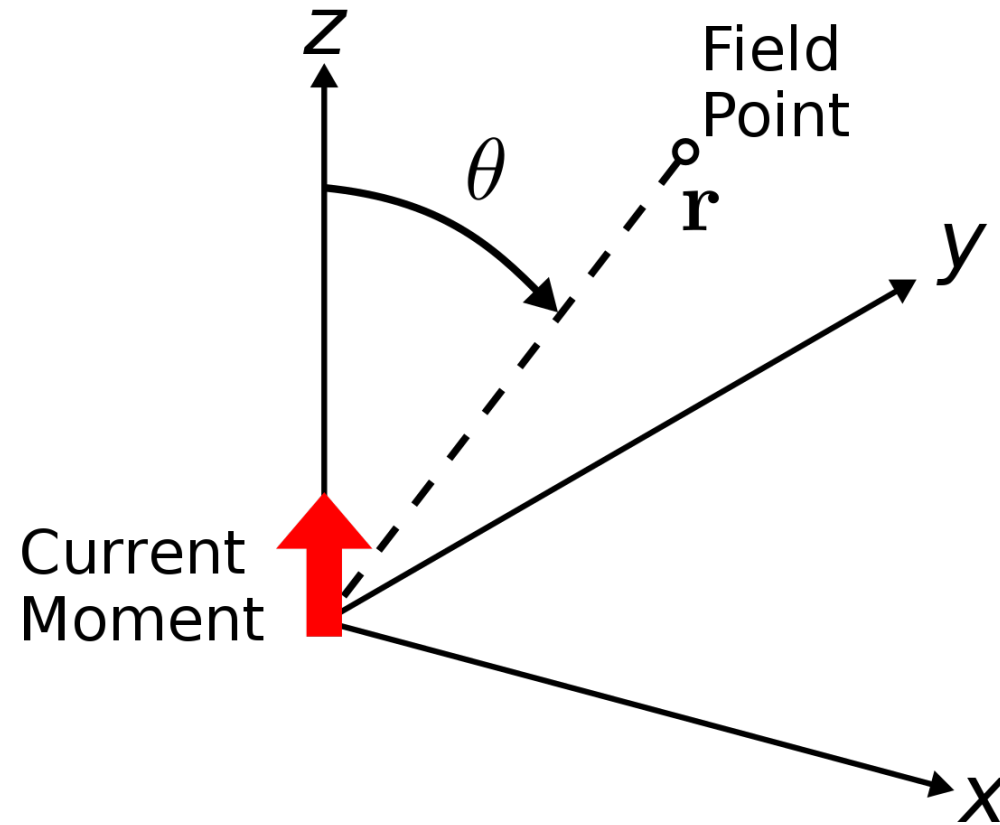


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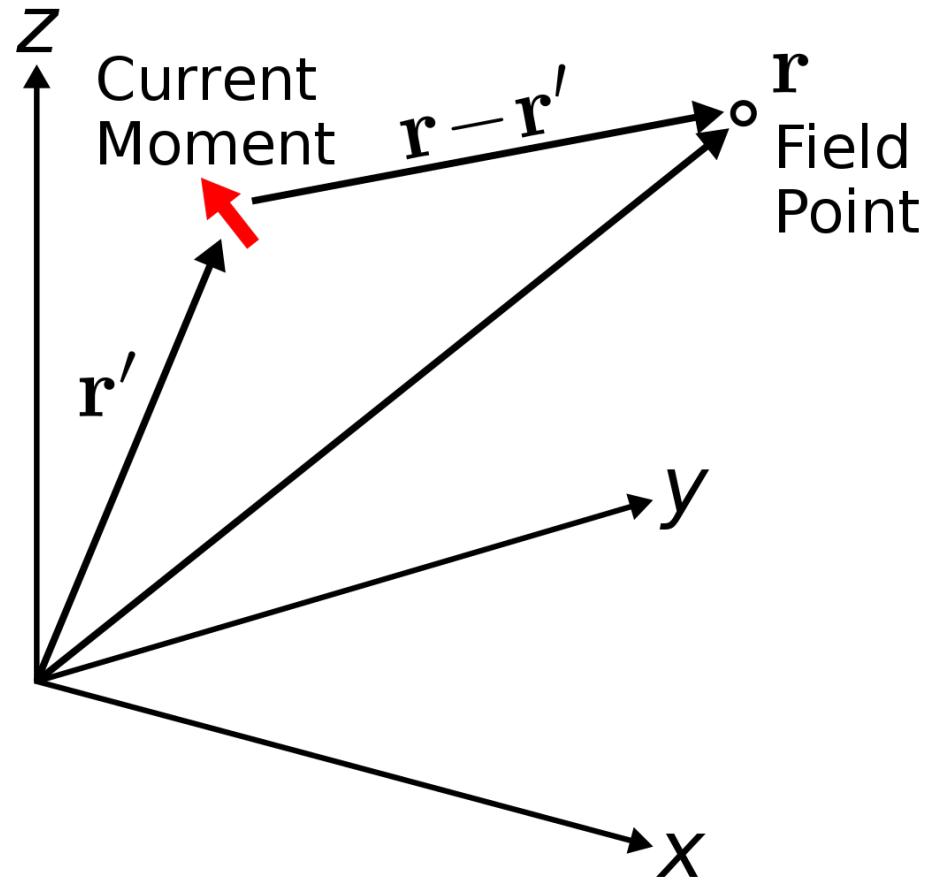


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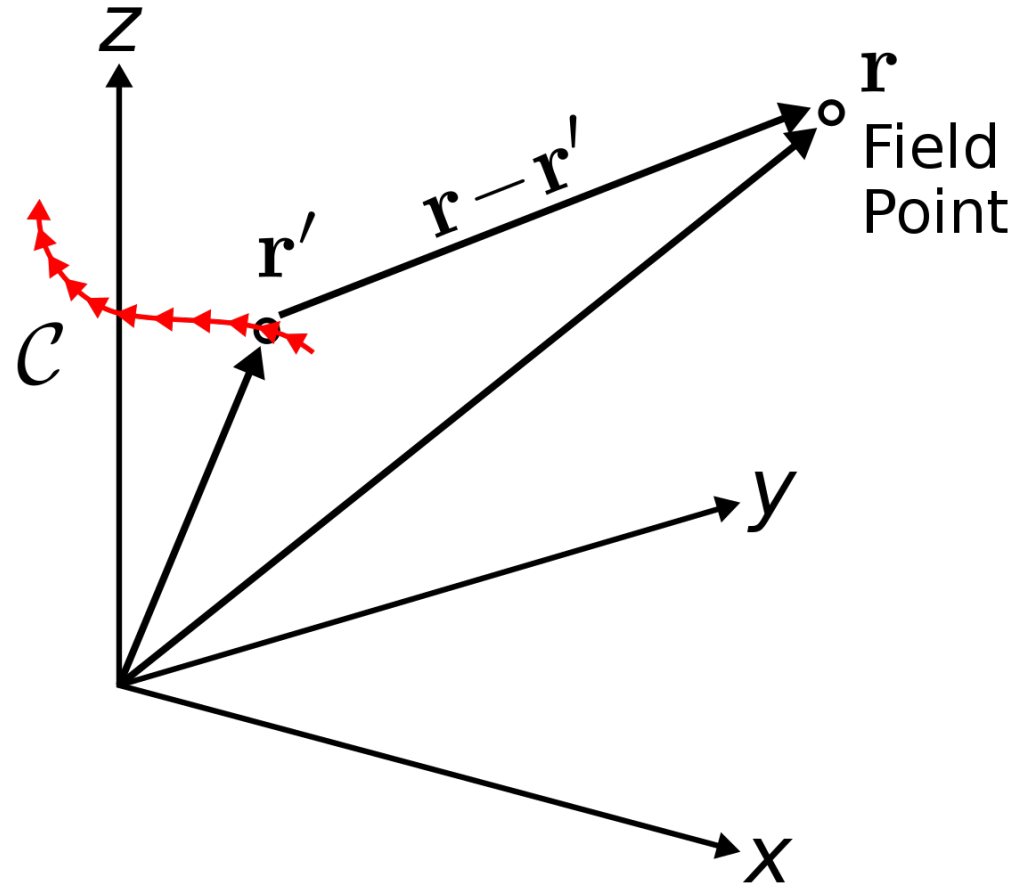


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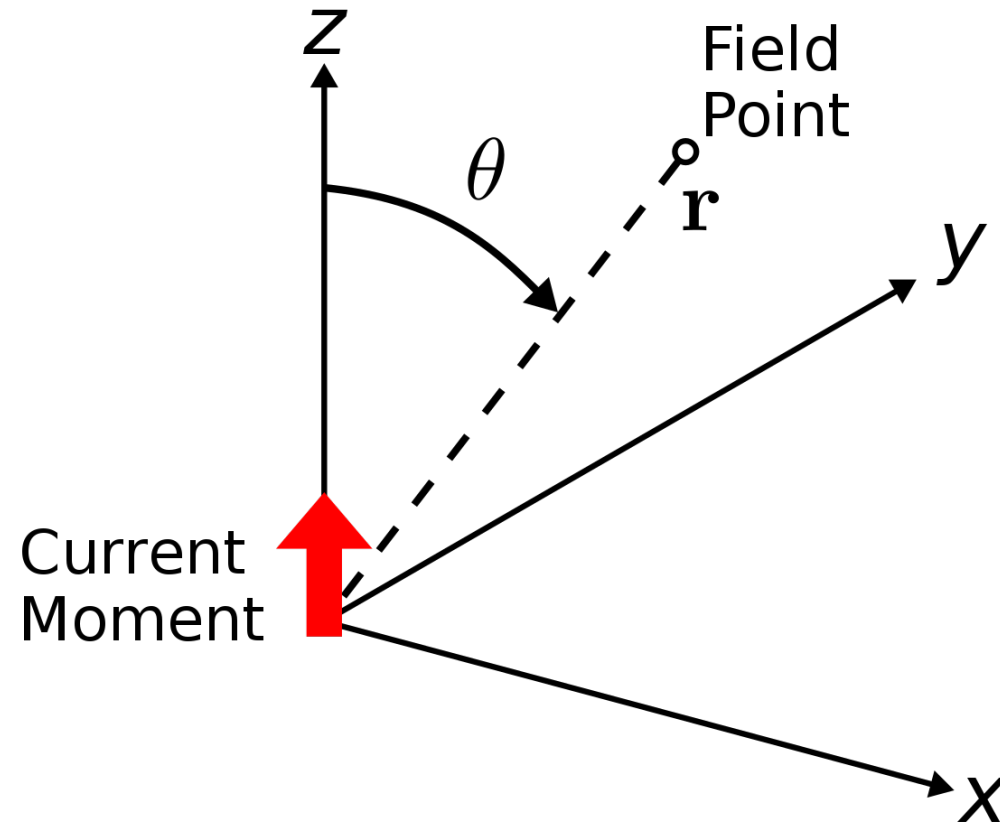


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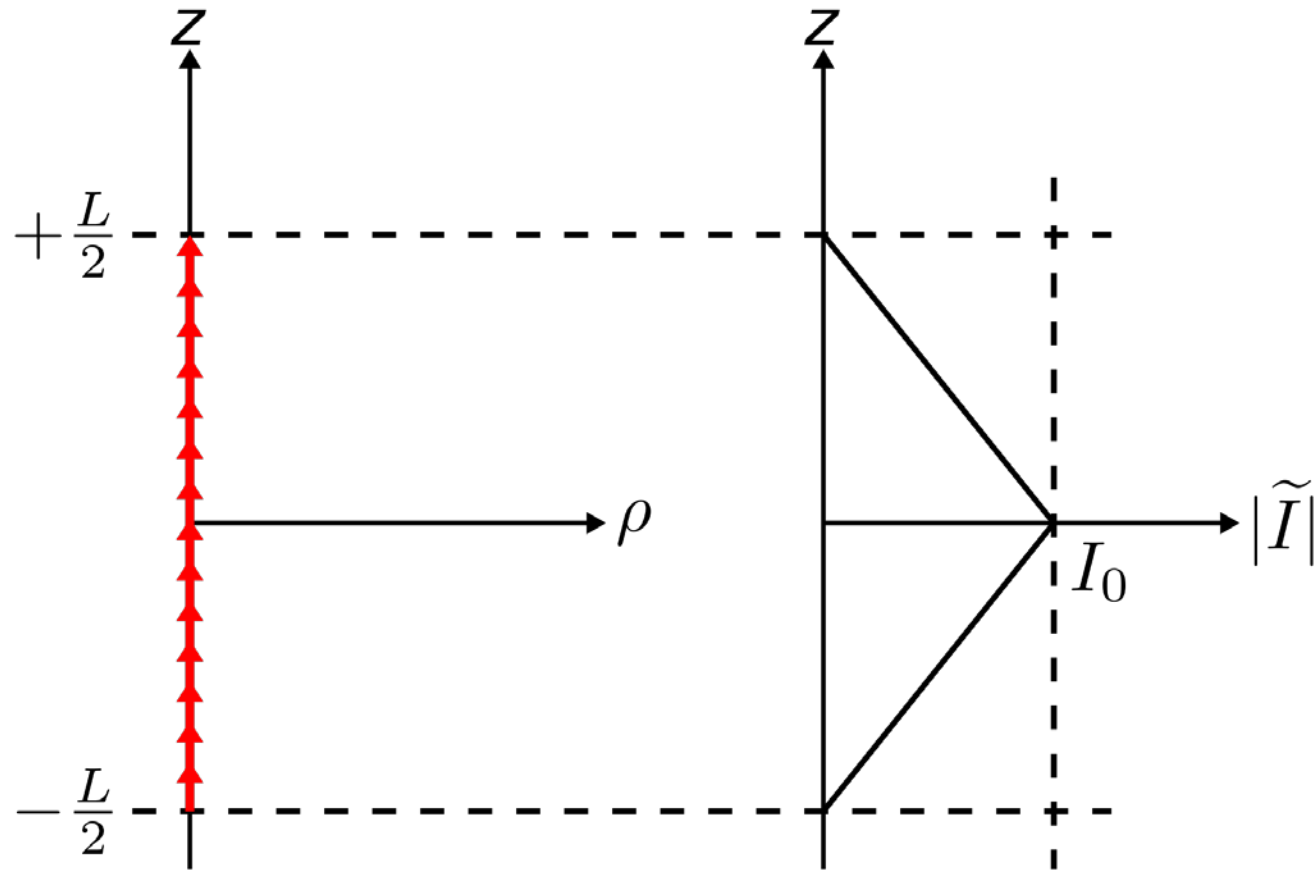


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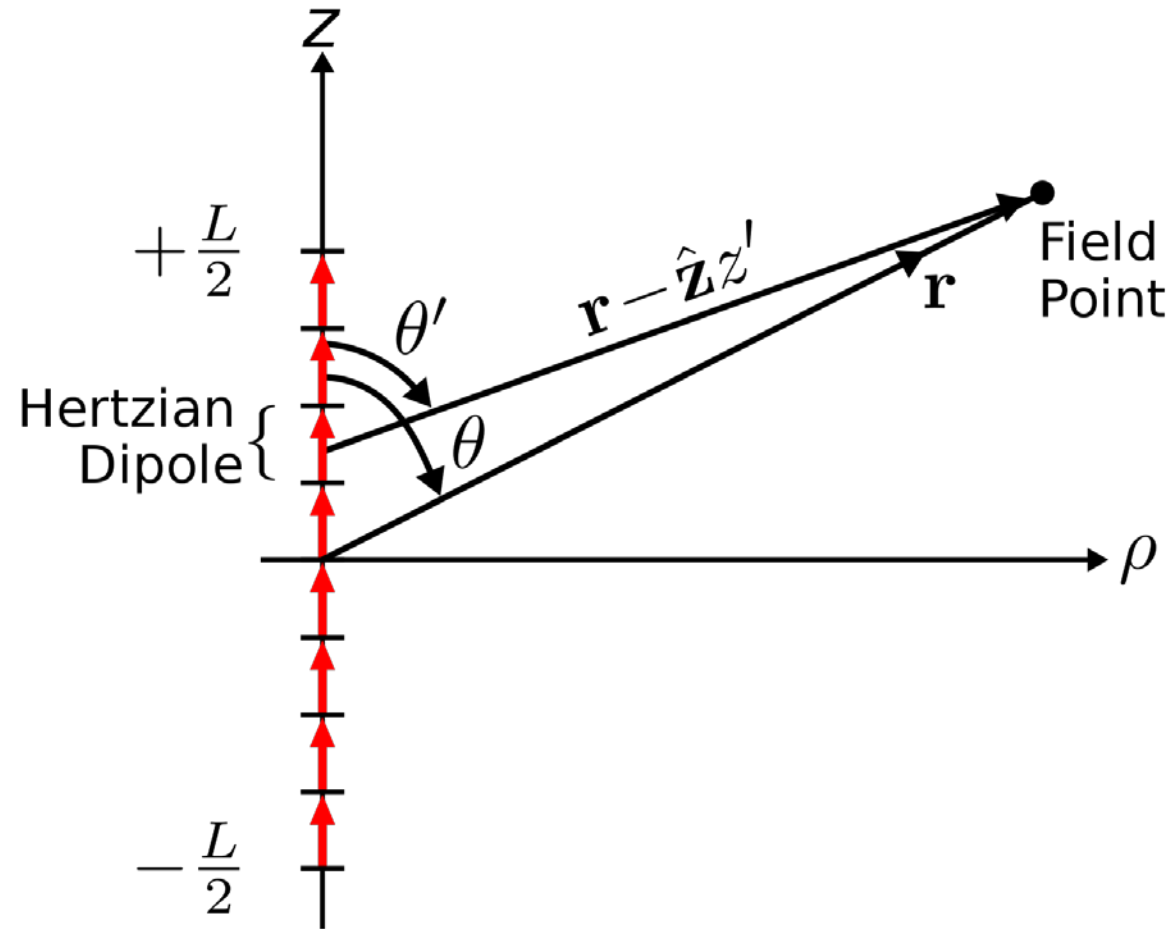


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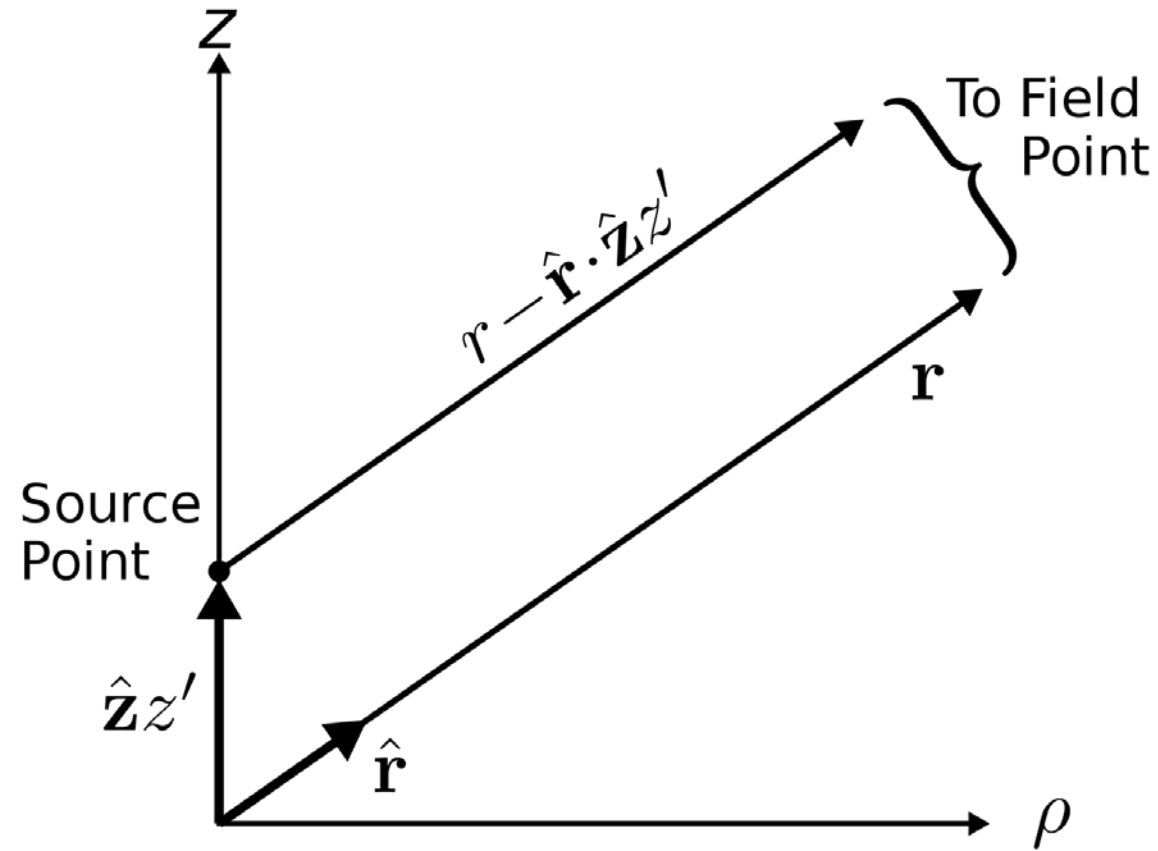


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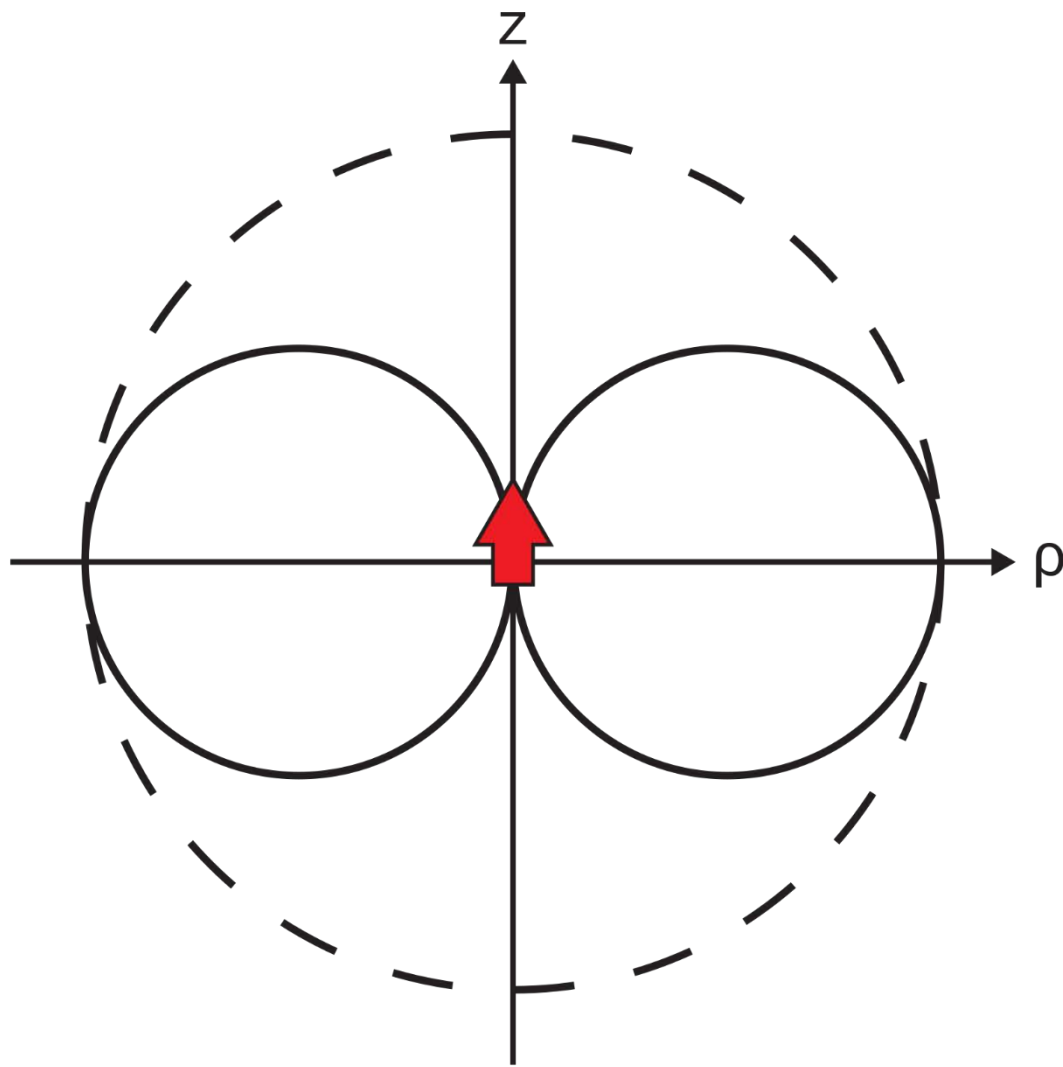


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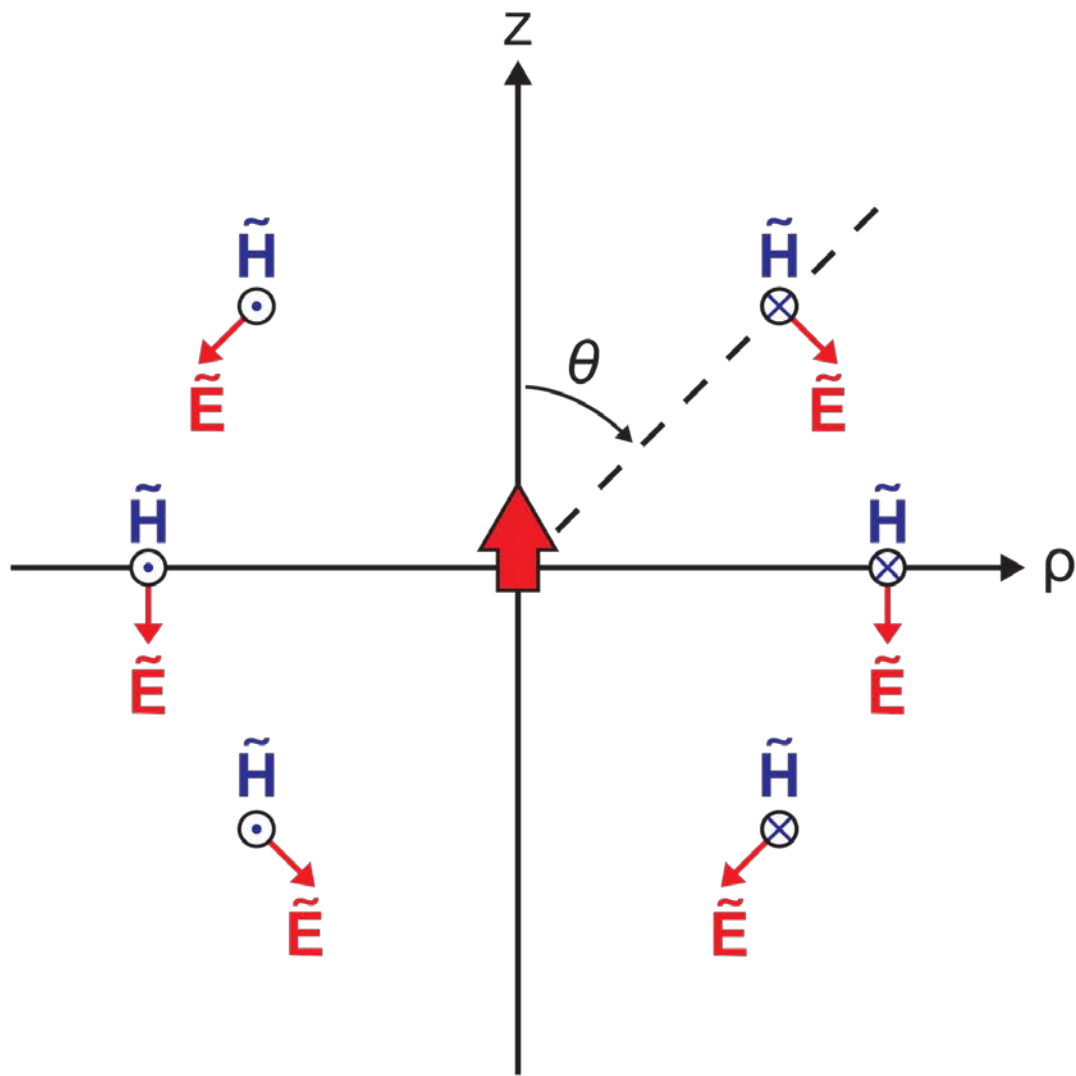


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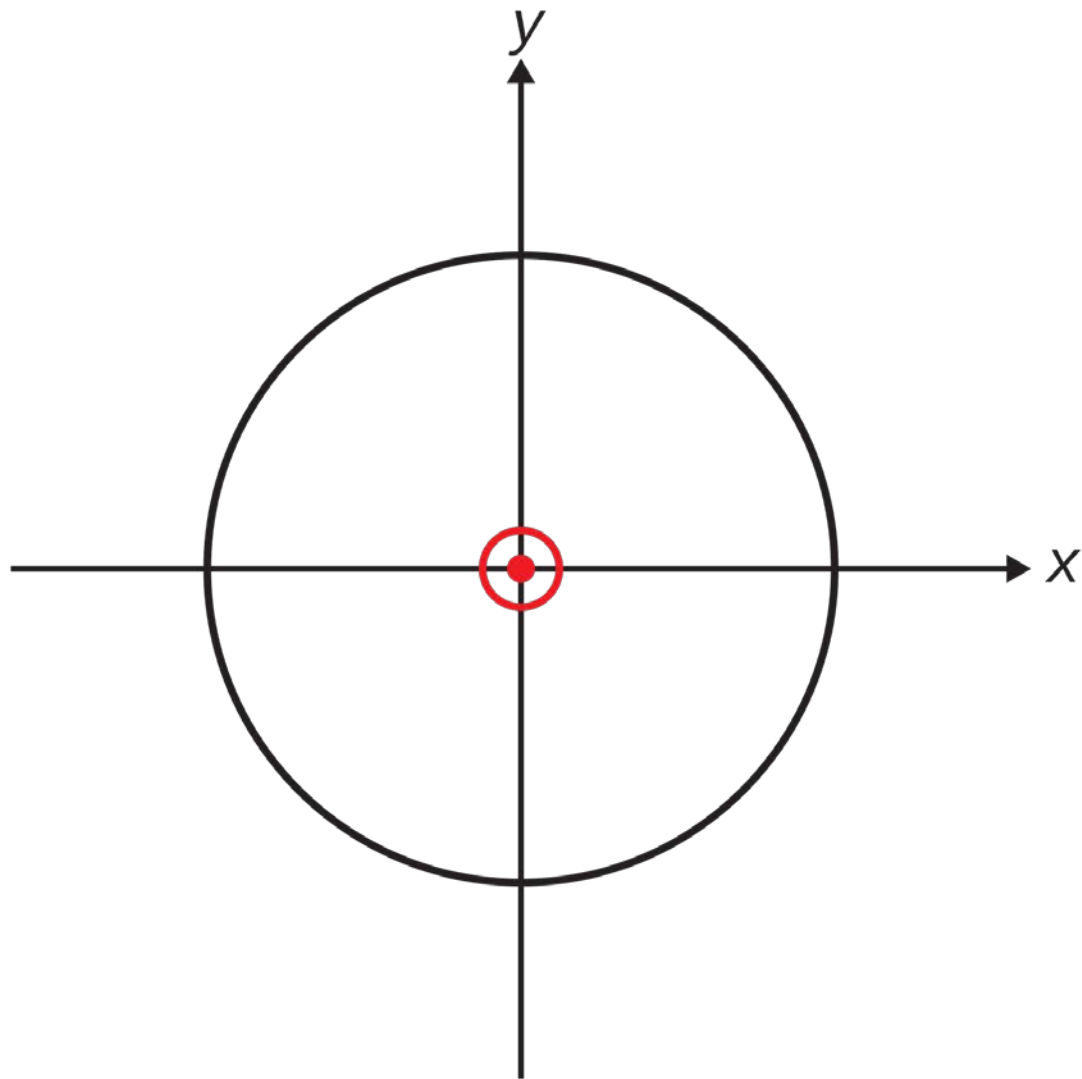


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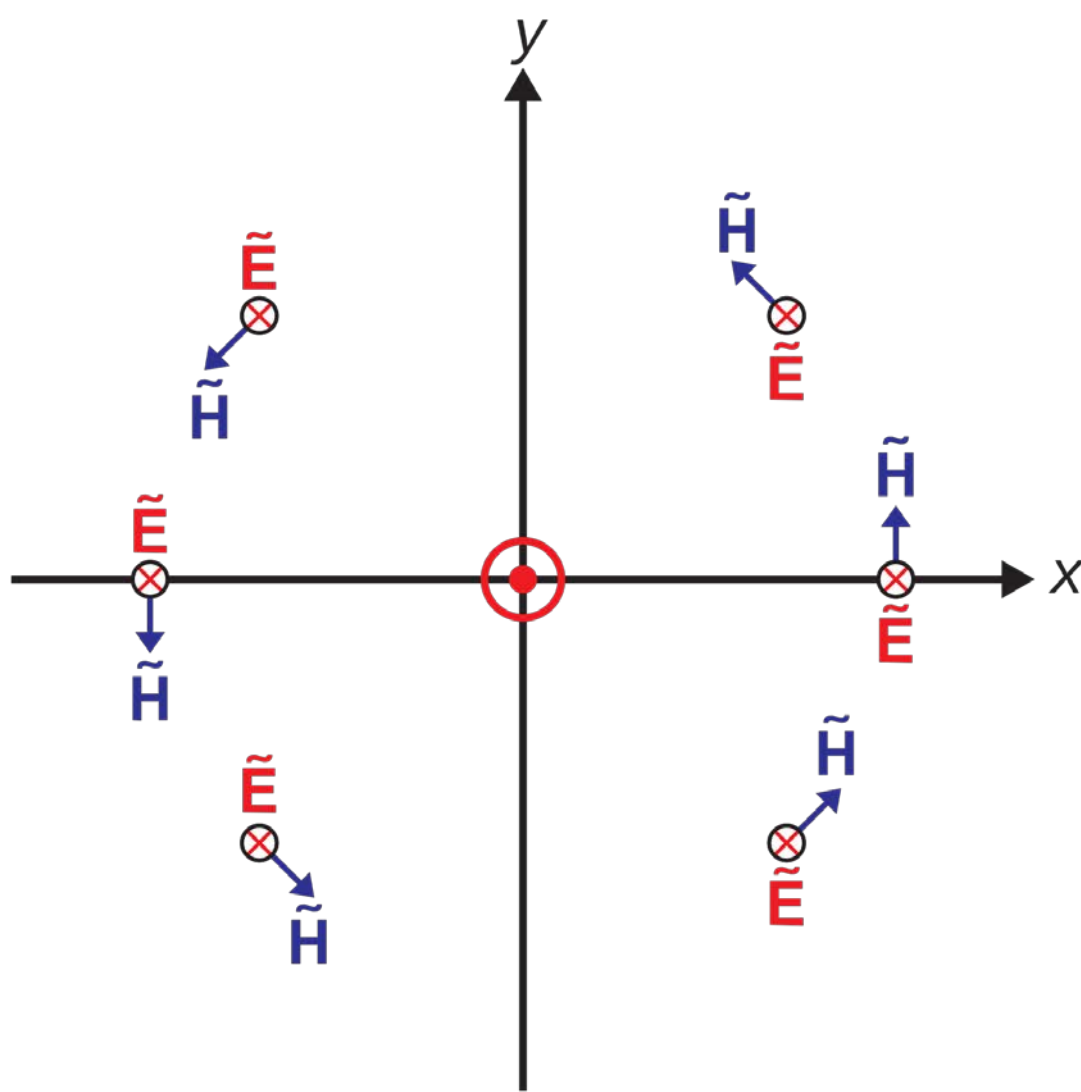


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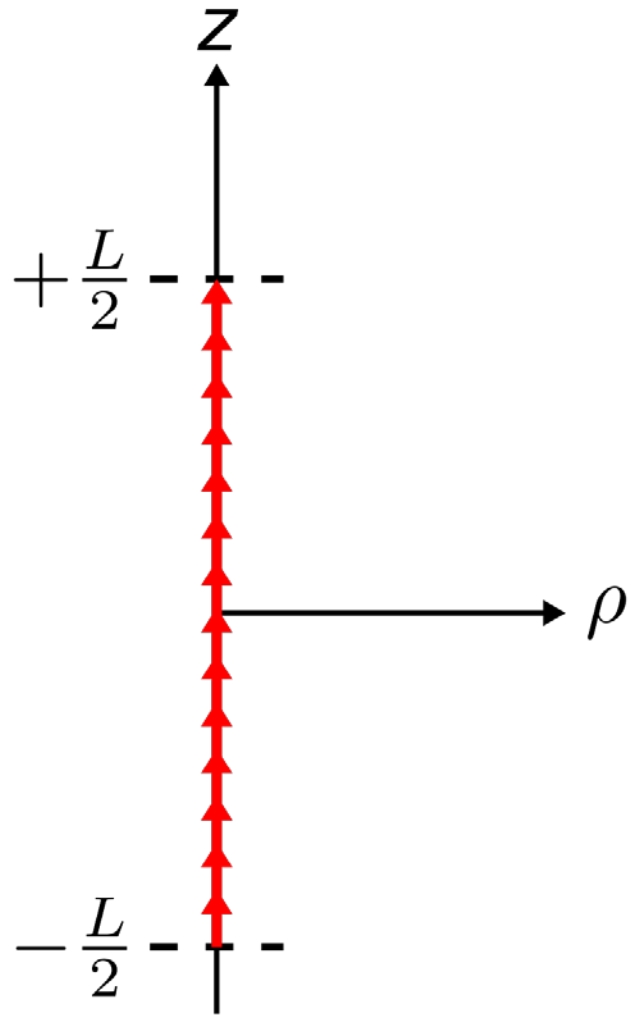


Fig. 9.13: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:A\\_thin\\_straight\\_distribution\\_of\\_radiating\\_current.svg](https://commons.wikimedia.org/wiki/File:A_thin_straight_distribution_of_radiating_current.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

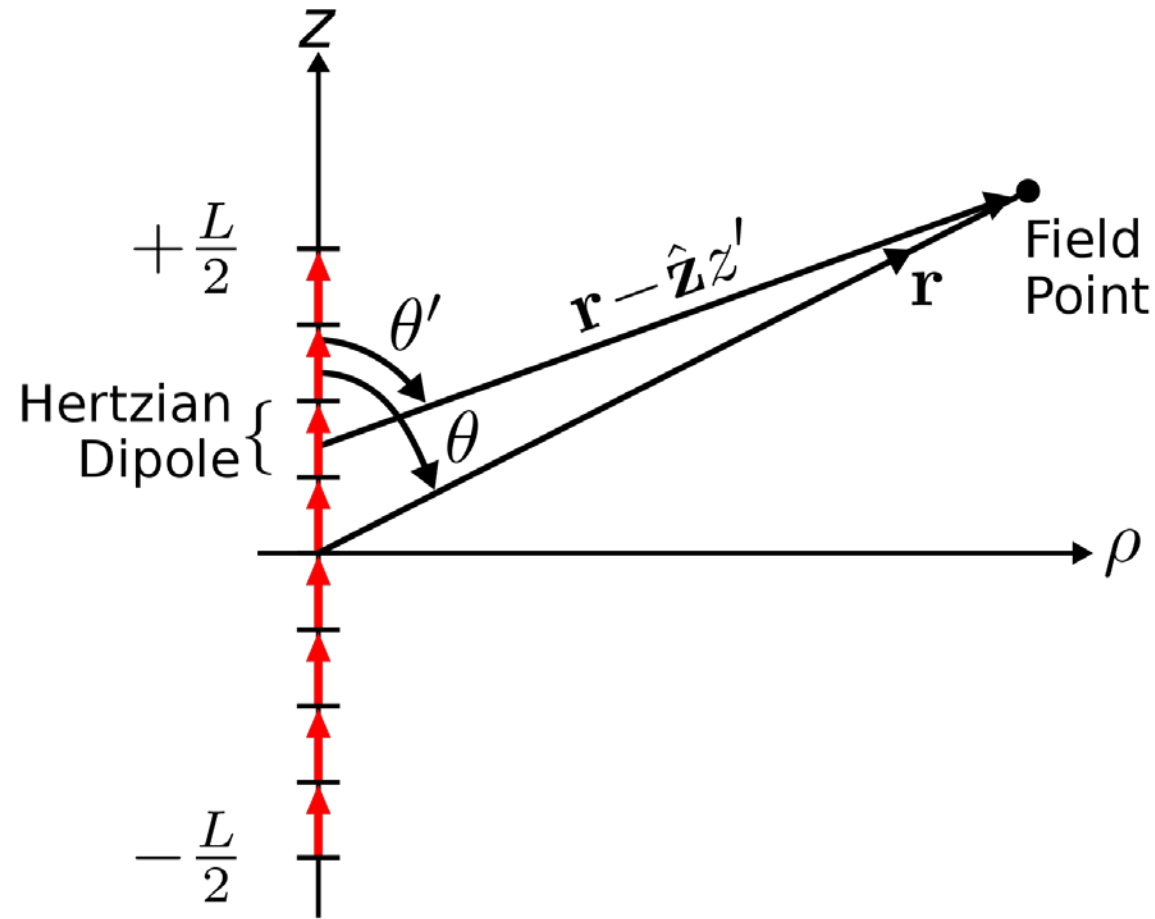


Fig. 9.14: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Esdsd\\_approximated\\_as\\_a\\_large\\_number\\_of\\_hertzian\\_dipoles.svg](https://commons.wikimedia.org/wiki/File:Esdsd_approximated_as_a_large_number_of_hertzian_dipoles.svg), CC BY-SA 4.0(<https://creativecommons.org/licenses/by-sa/4.0/>).

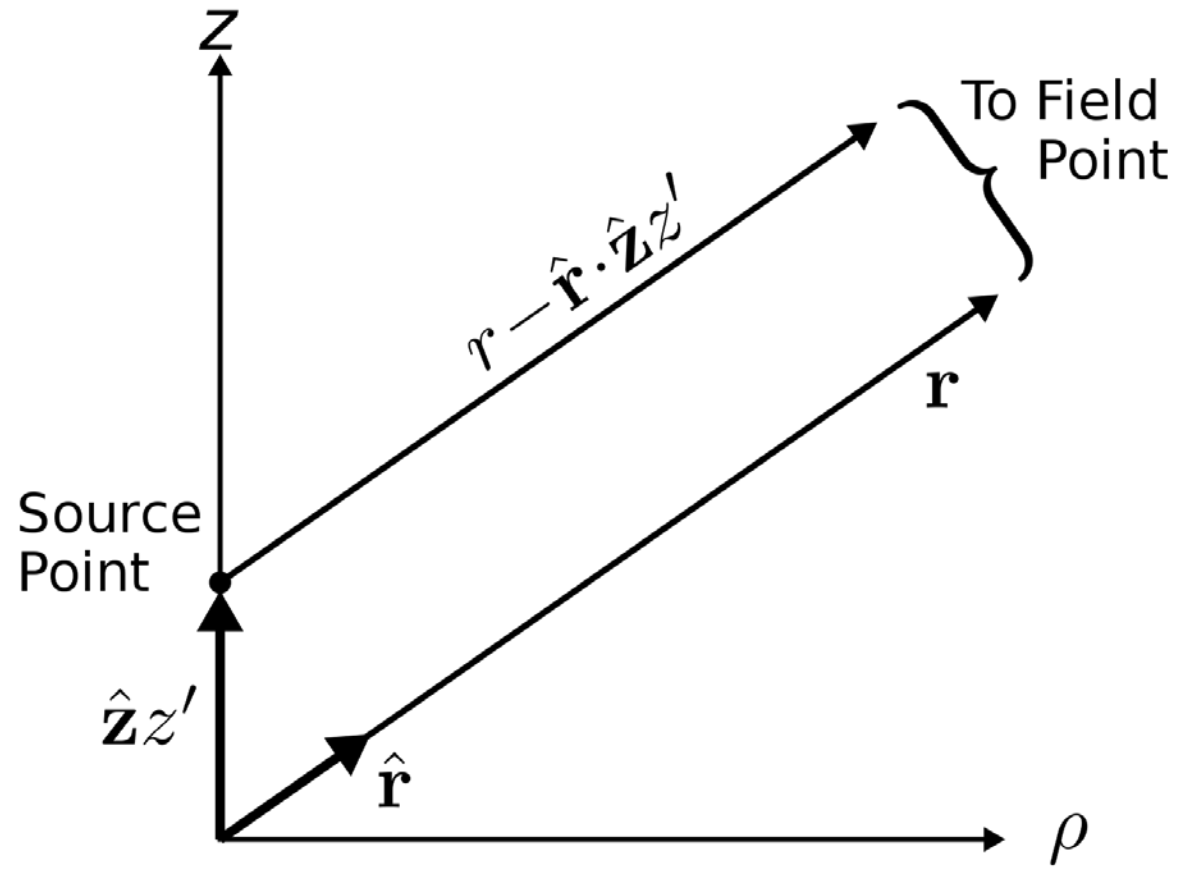


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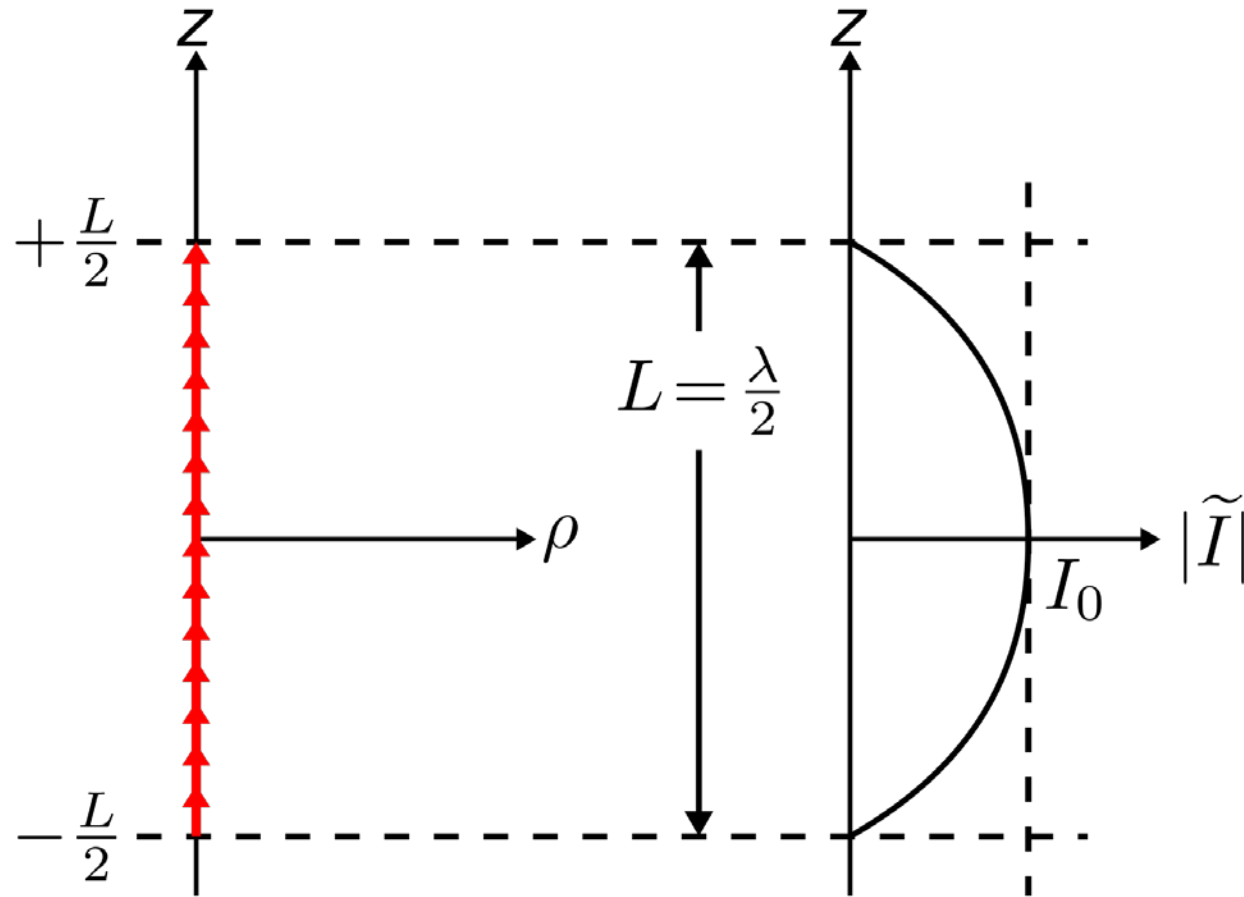


Fig. 9.16: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Current distribution of the hwd.svg](https://commons.wikimedia.org/wiki/File:Current_distribution_of_the_half_wave_dipole.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).



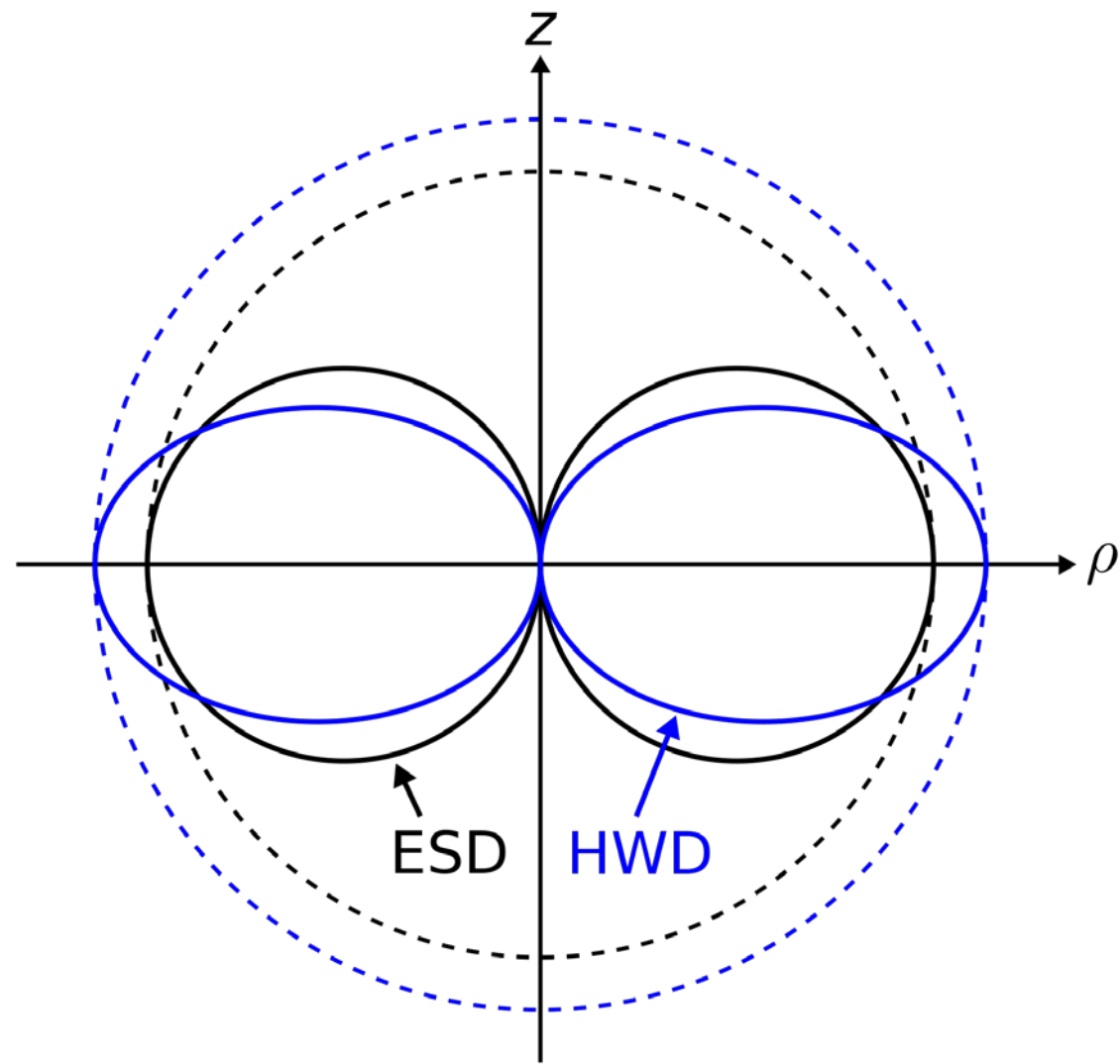


Fig. 9.17: © Sevenchw (C. Wang), [https://commons.wikimedia.org/wiki/File:Comparison radiated field magnitude of hwd to esd.svg](https://commons.wikimedia.org/wiki/File:Comparison_radiated_field_magnitude_of_hwd_to_esd.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

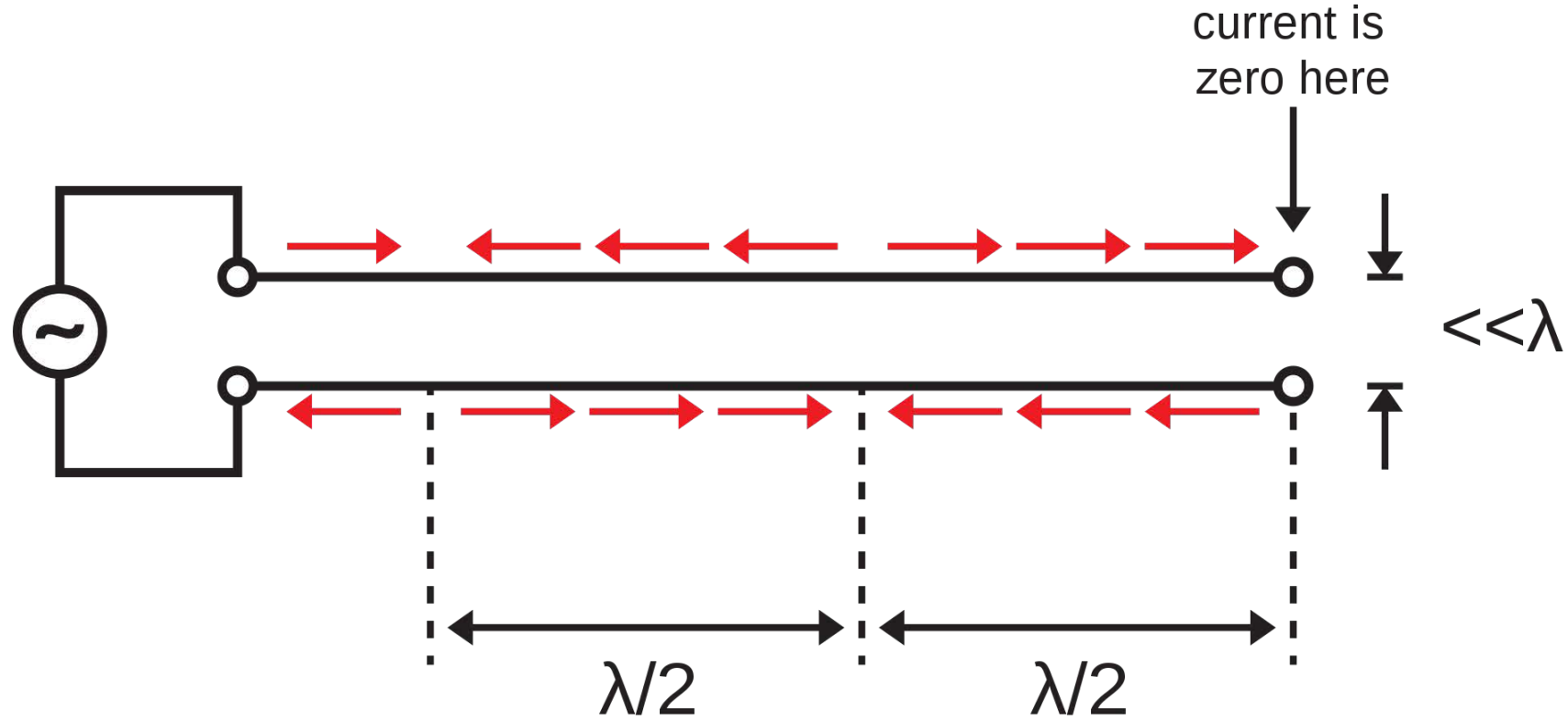


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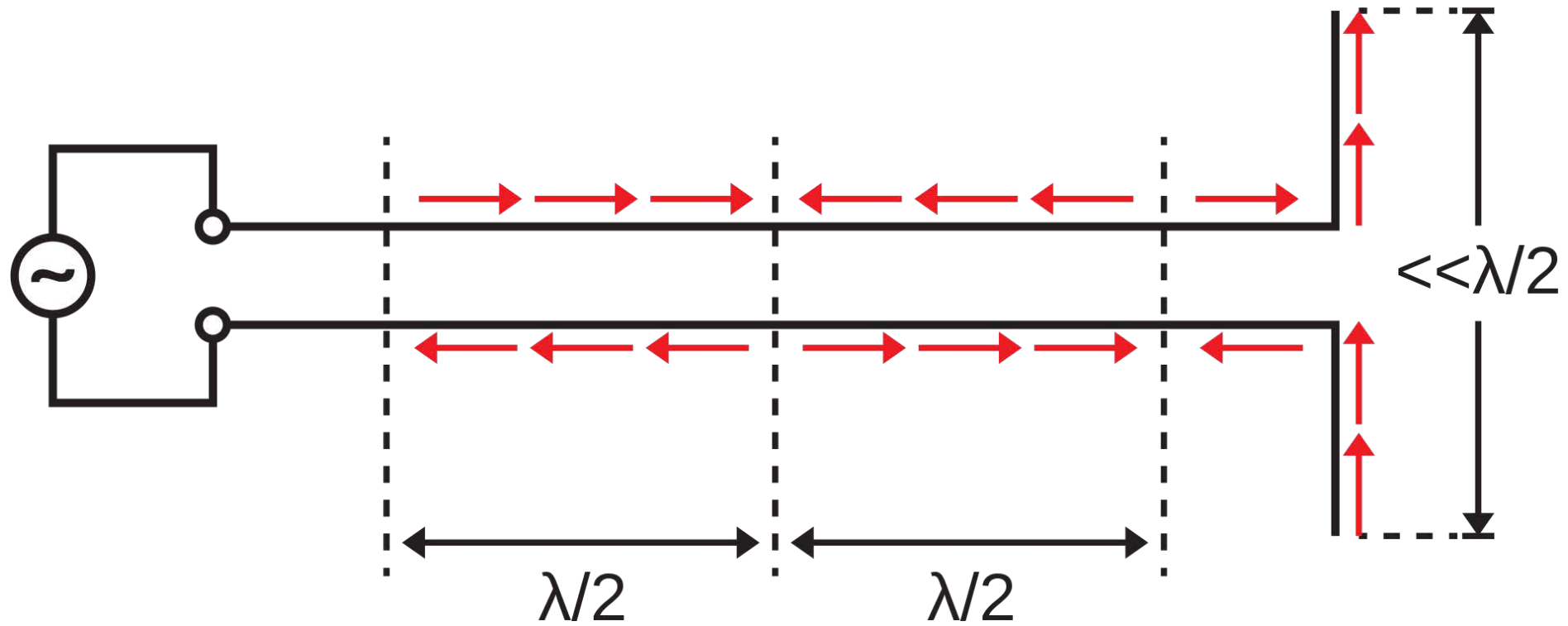


Fig. 10.2: © Offaperry (S. Lally), [https://commons.wikimedia.org/wiki/File:Electrically-Short Dipole.svg](https://commons.wikimedia.org/wiki/File:Electrically-Short_Dipole.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

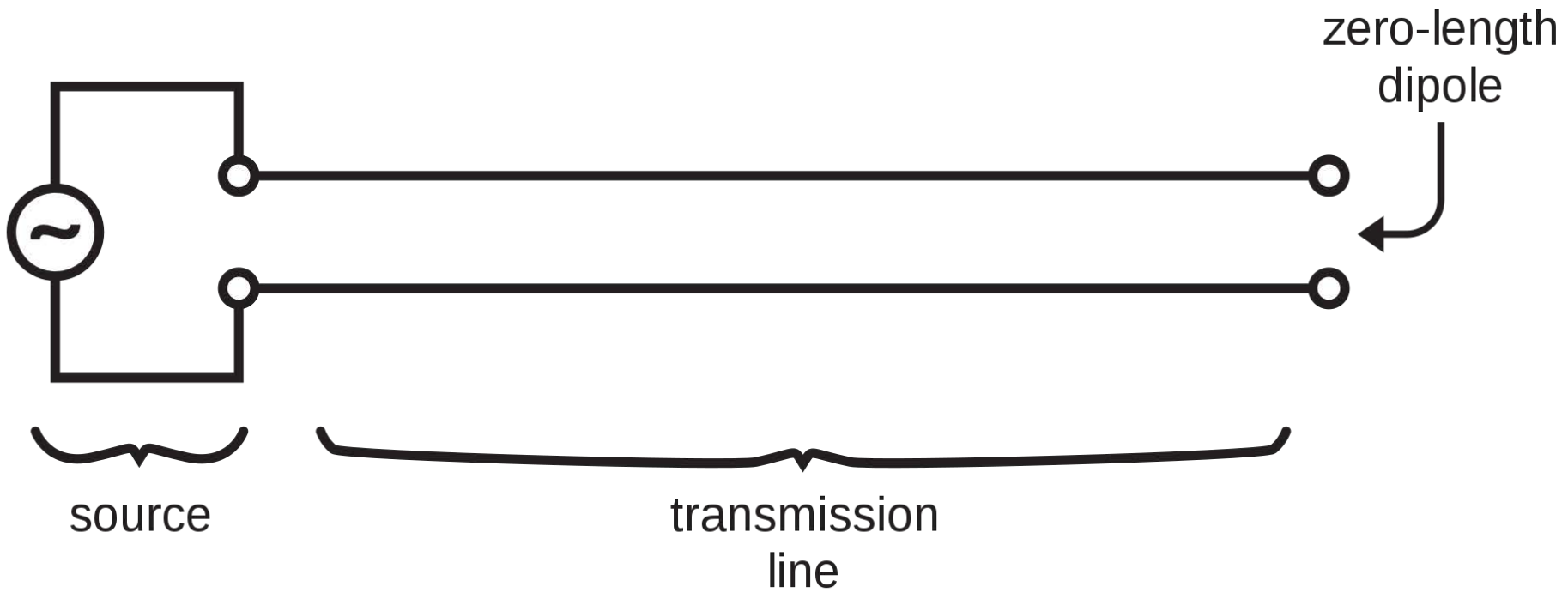


Fig. 10.3: © Offaperry (S. Lally), [https://commons.wikimedia.org/wiki/File:Zero-Length Dipole Open Circuit.svg](https://commons.wikimedia.org/wiki/File:Zero-Length_Dipole_Open_Circuit.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

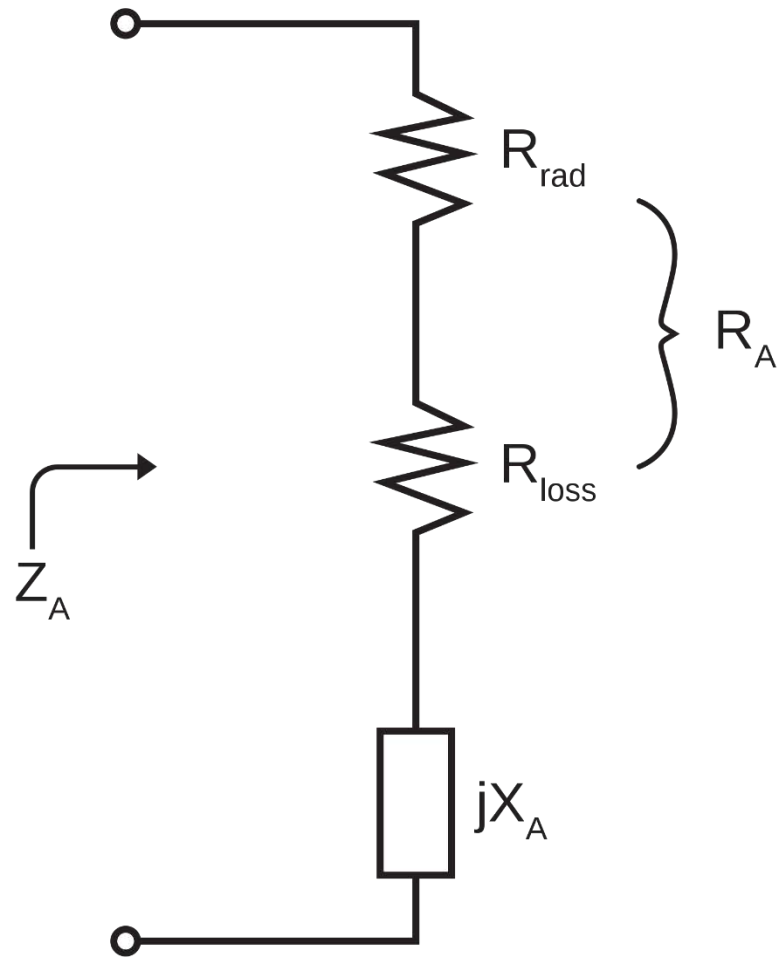


Fig. 10.4: © Offaperry (S. Lally), [https://commons.wikimedia.org/wiki/File:Transmitting Antenna Circuit.svg](https://commons.wikimedia.org/wiki/File:Transmitting_Antenna_Circuit.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>).

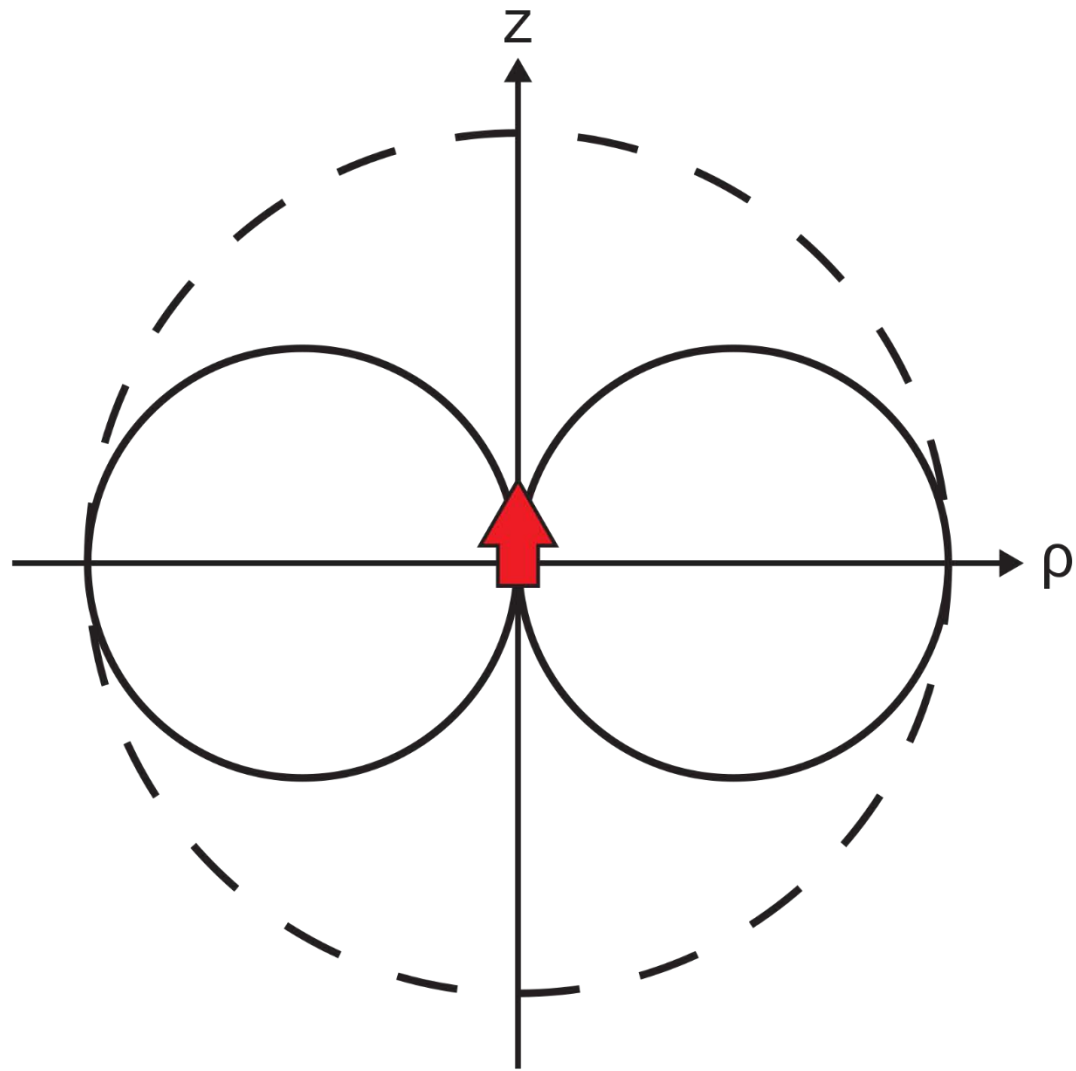


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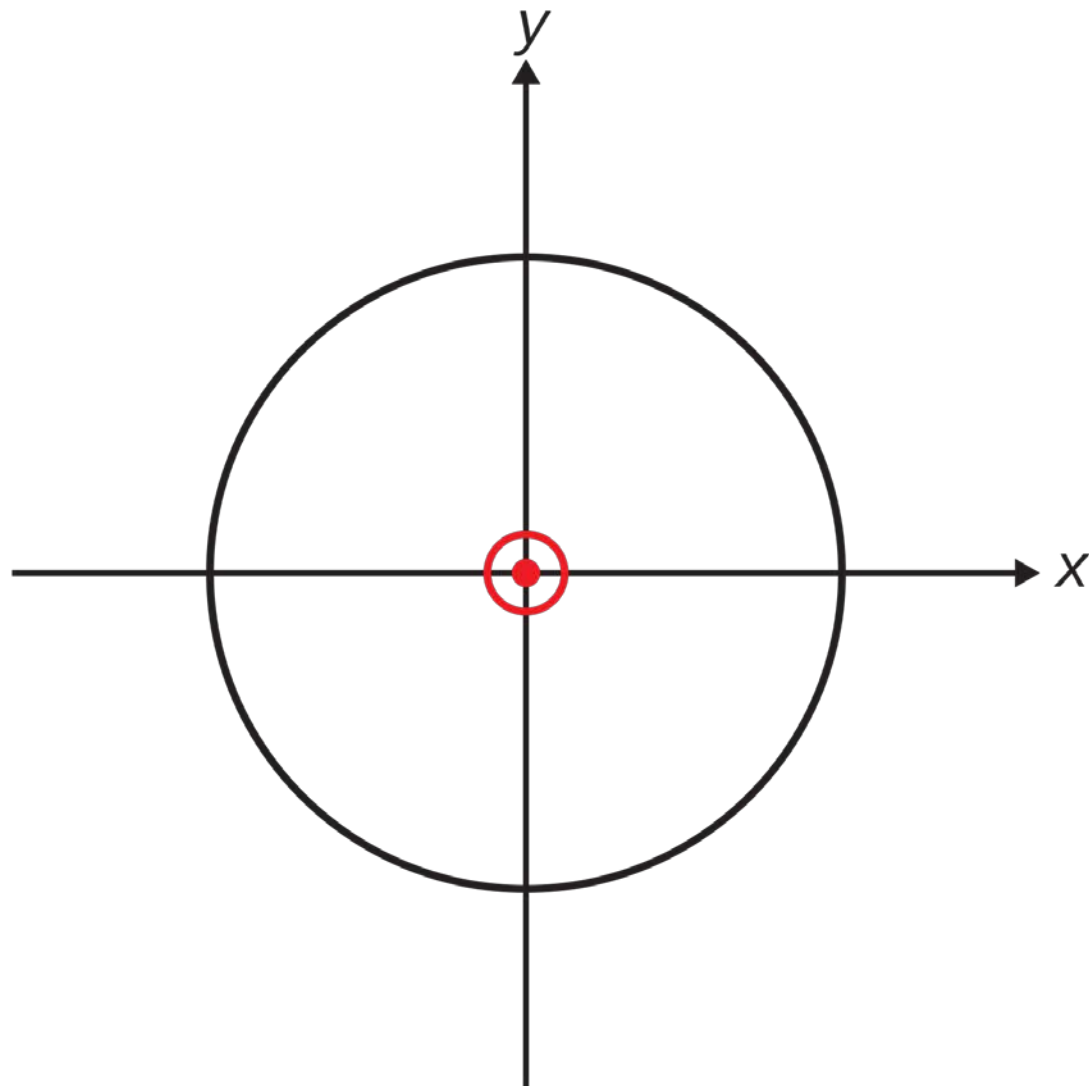


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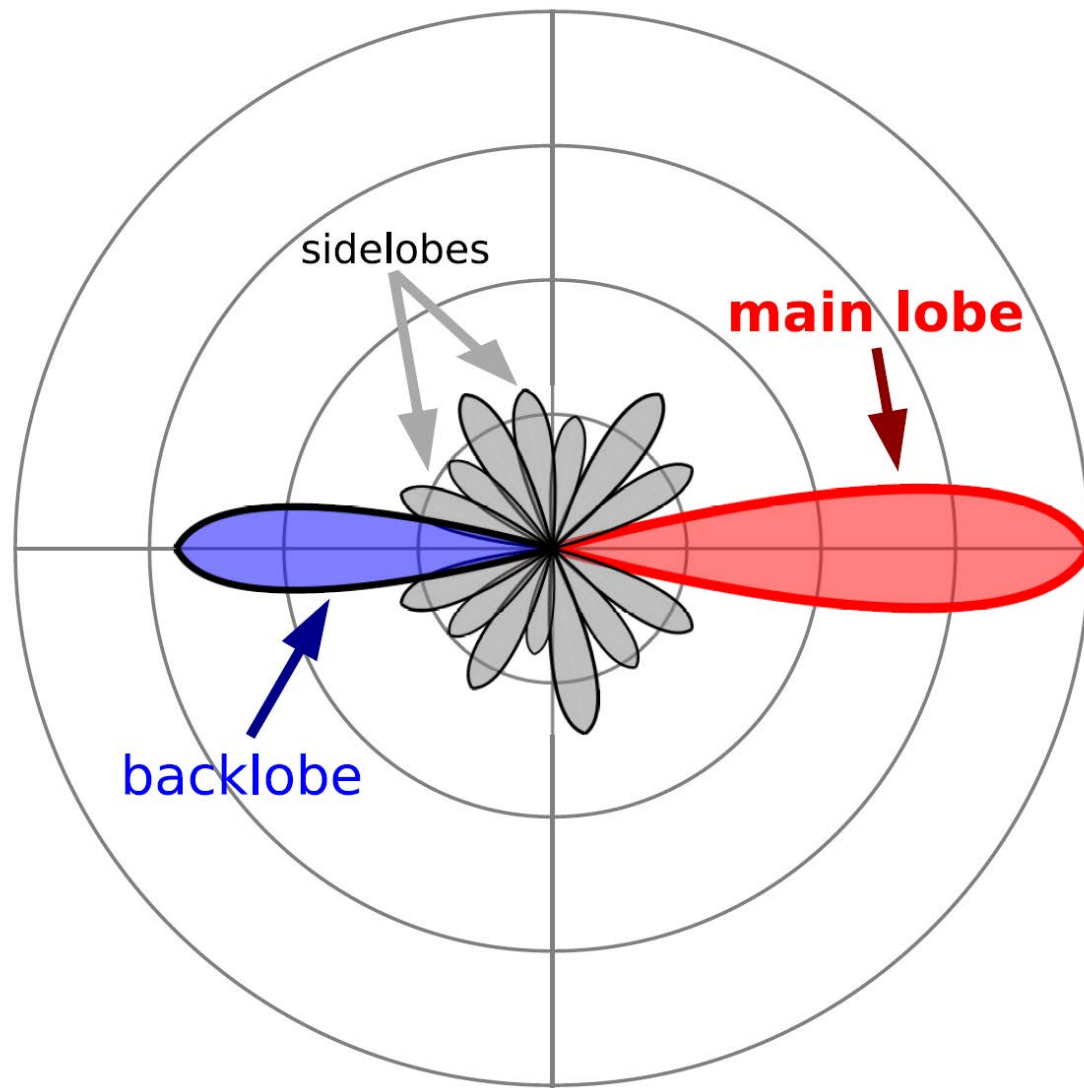


Fig. 10.7: © T. Truckle, [https://en.wikipedia.org/wiki/File:Sidelobes\\_en.svg](https://en.wikipedia.org/wiki/File:Sidelobes_en.svg), CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>). Modified.



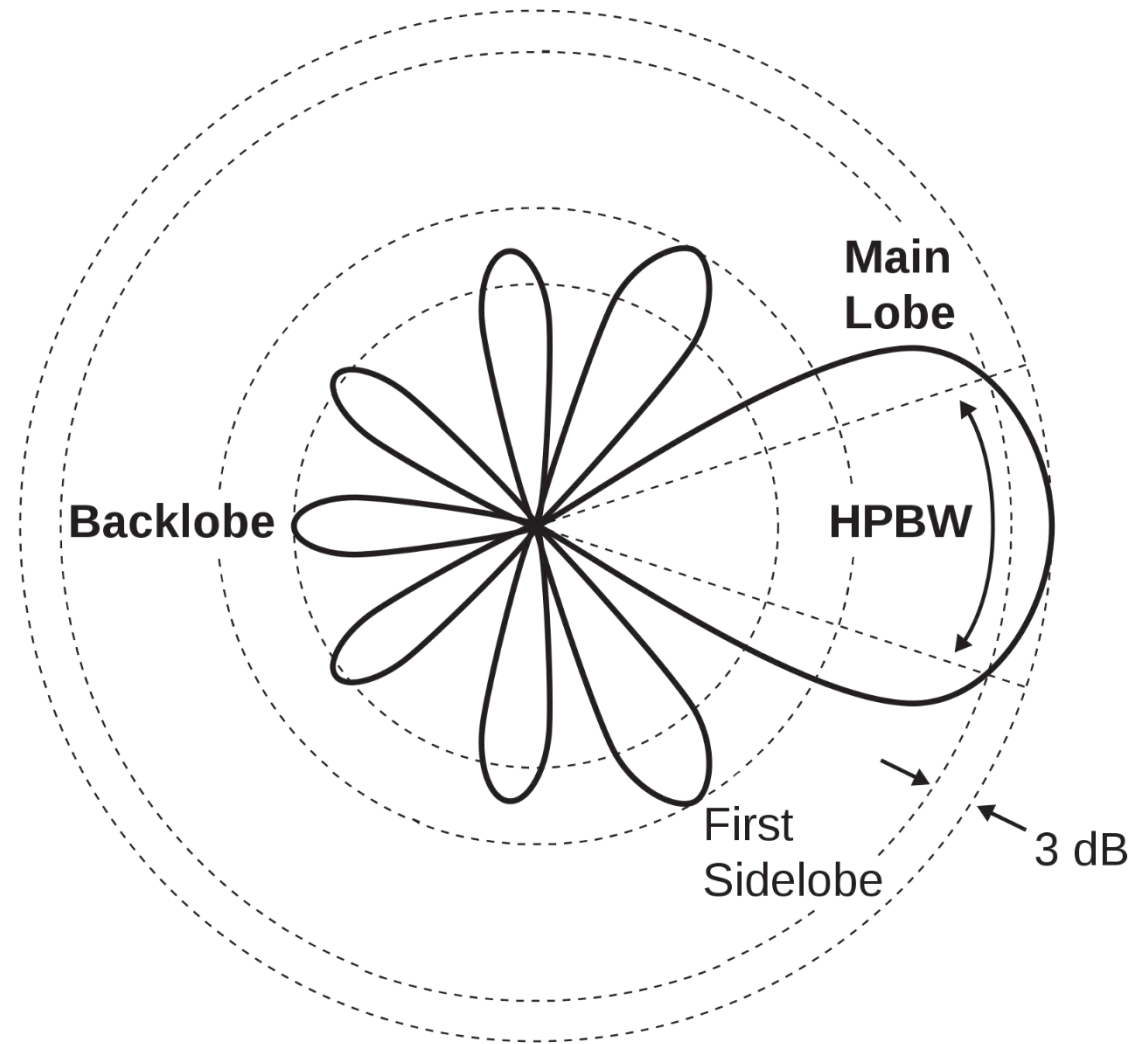


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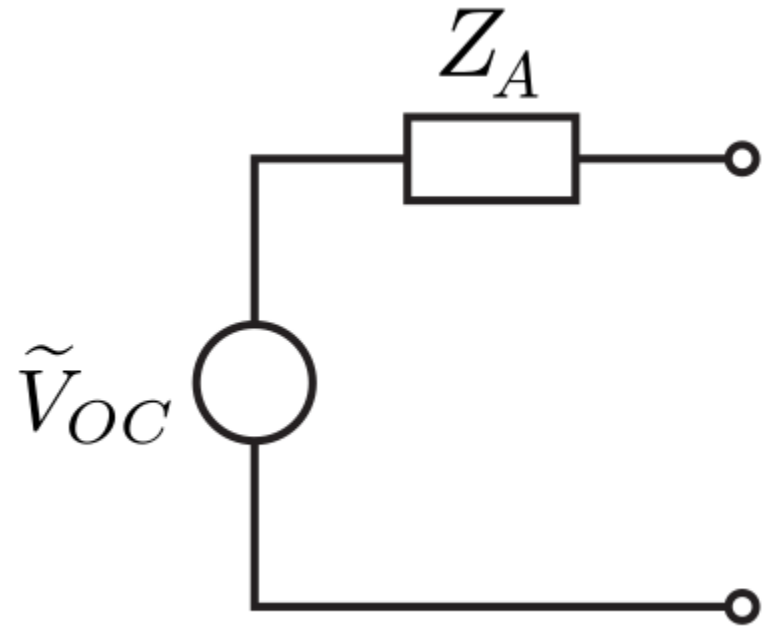


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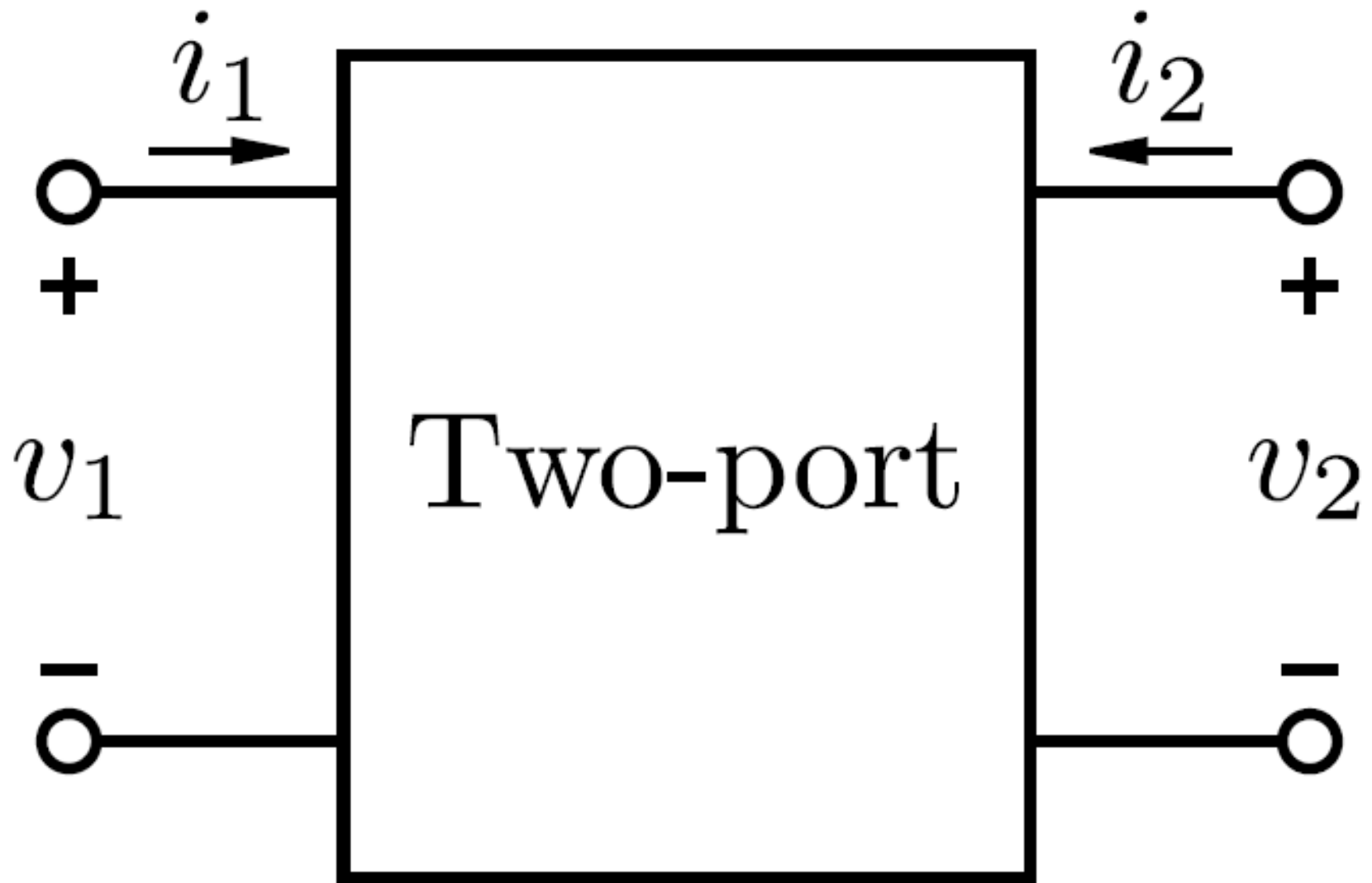


Fig. 10.10: Inductiveload, [https://commons.wikimedia.org/wiki/File:Two Port Circuit.svg](https://commons.wikimedia.org/wiki/File:Two_Port_Circuit.svg), public domain. Modified.

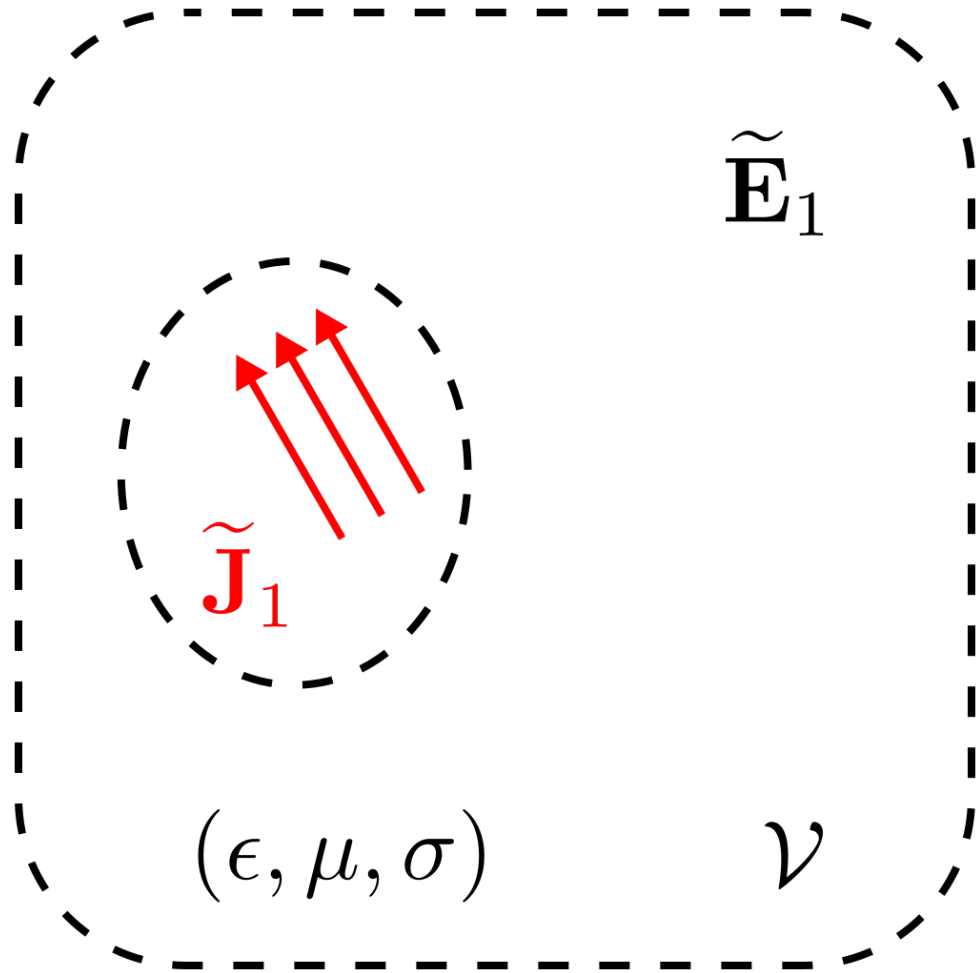


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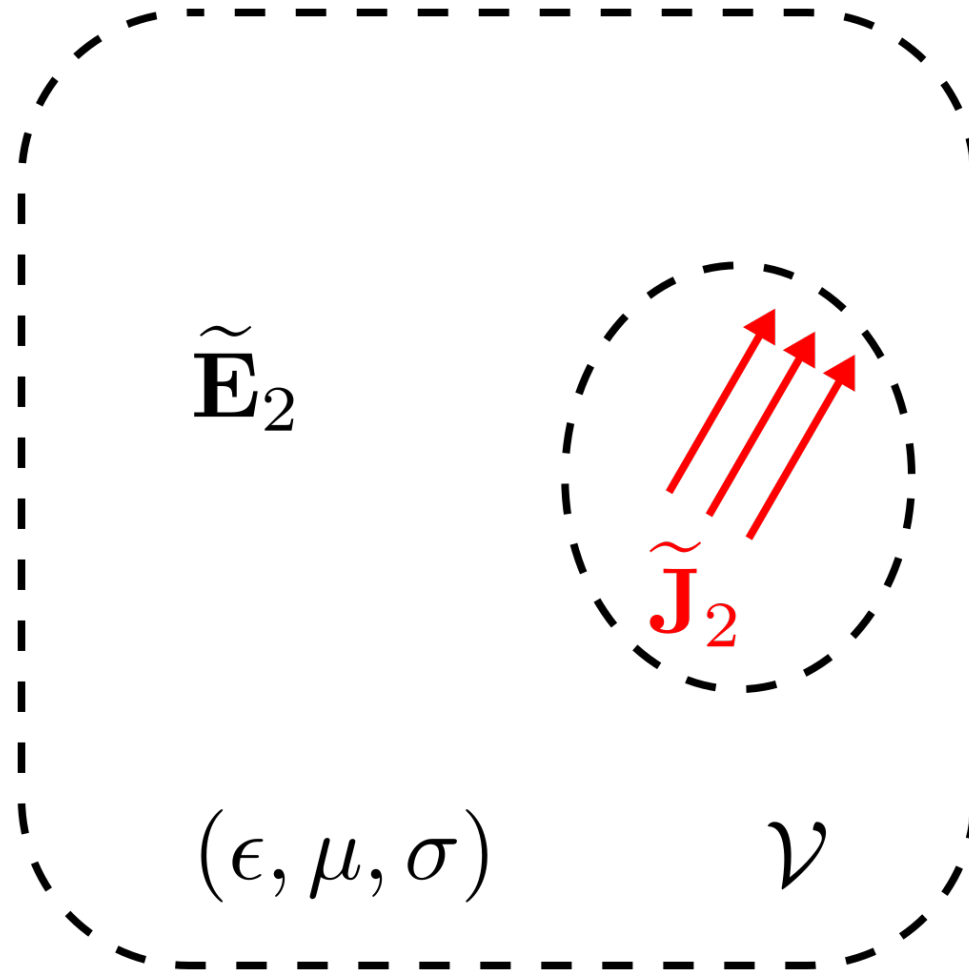


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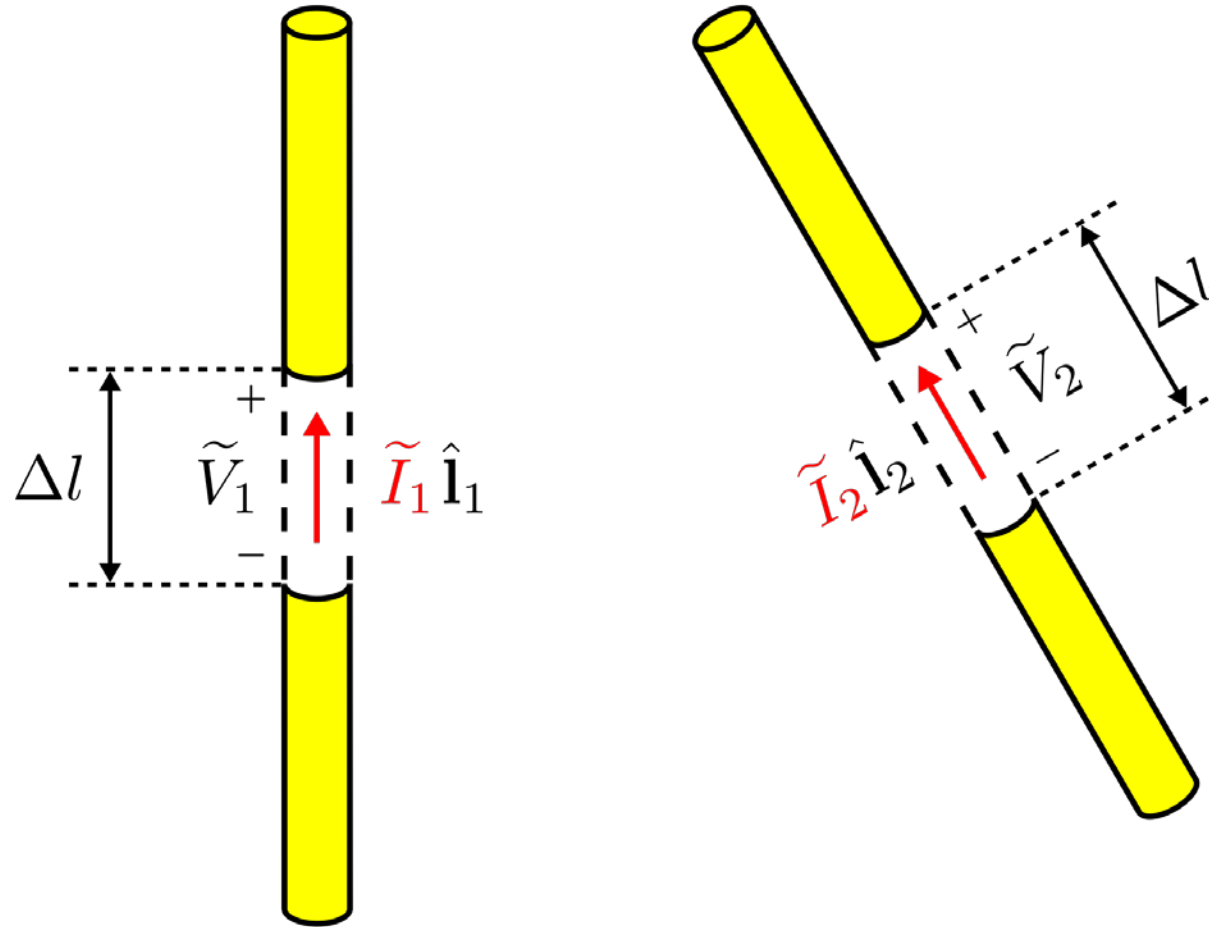


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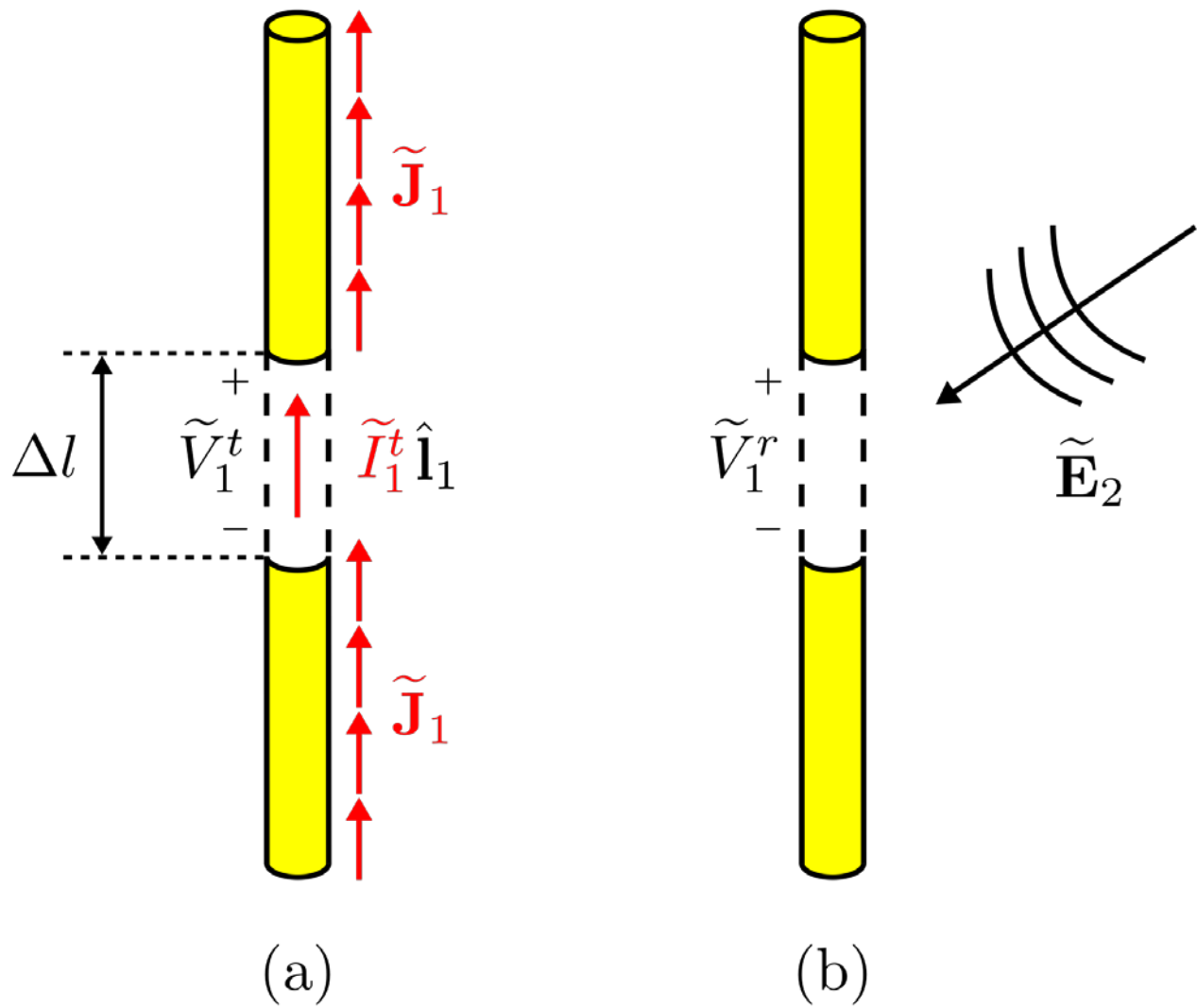


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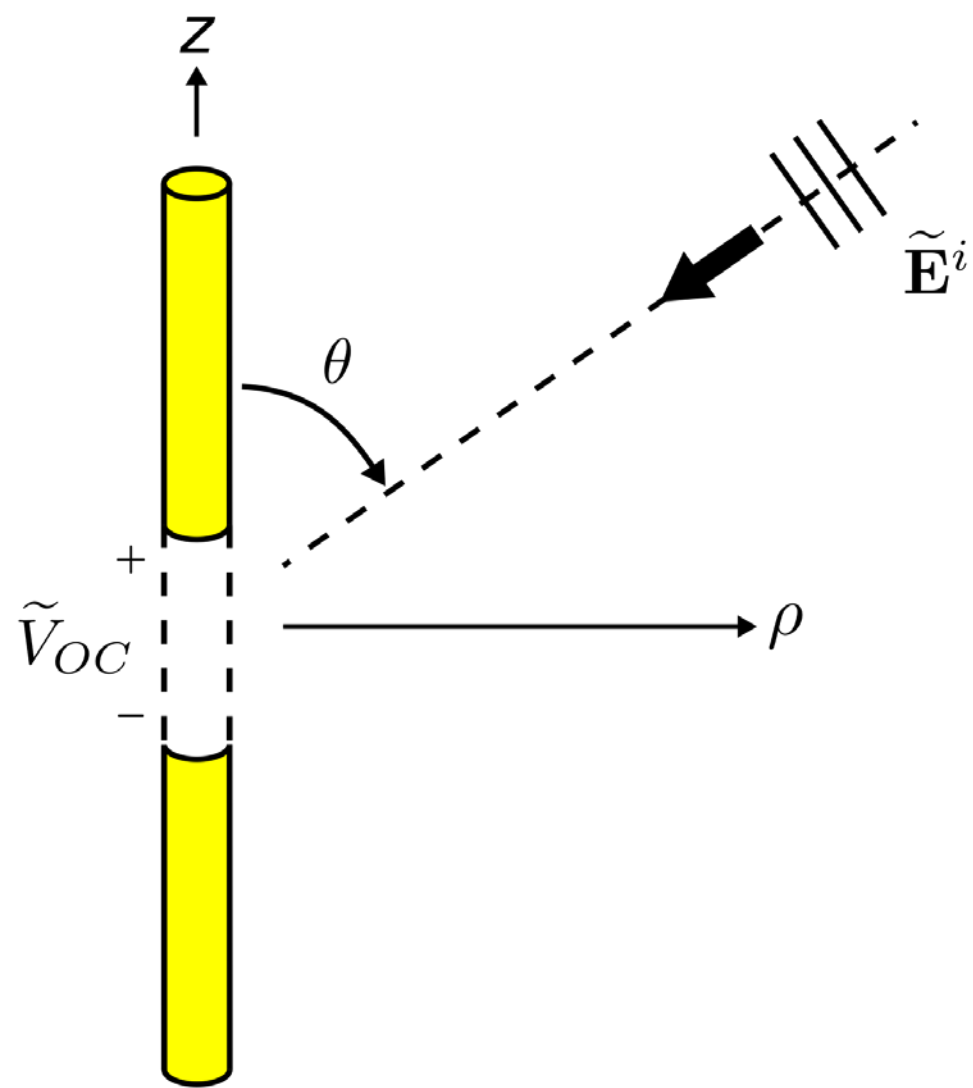


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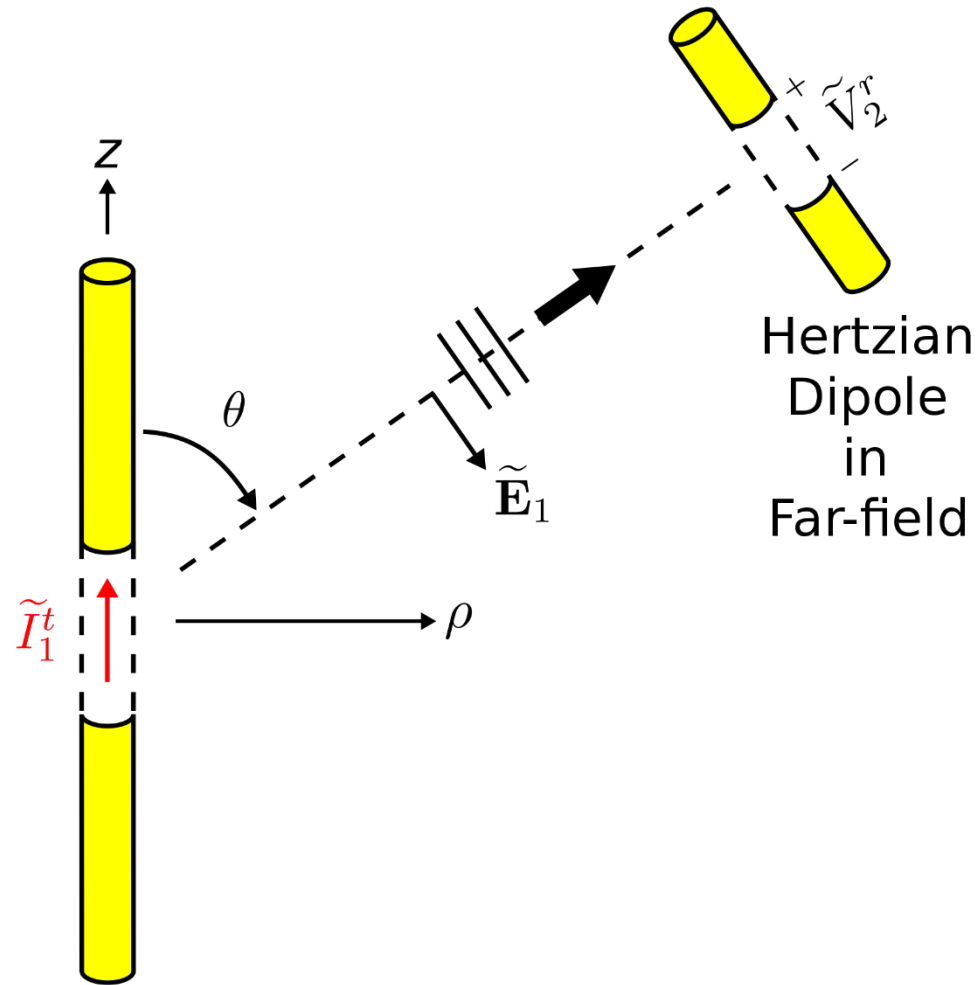


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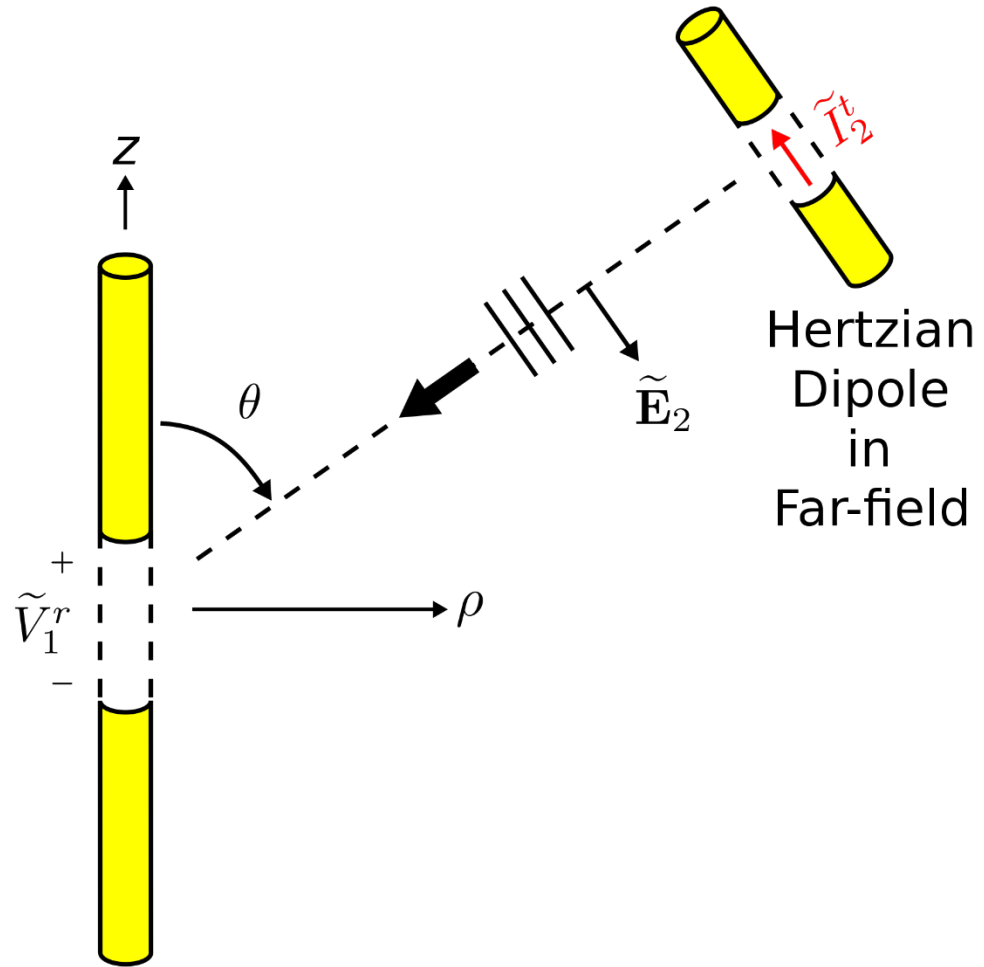


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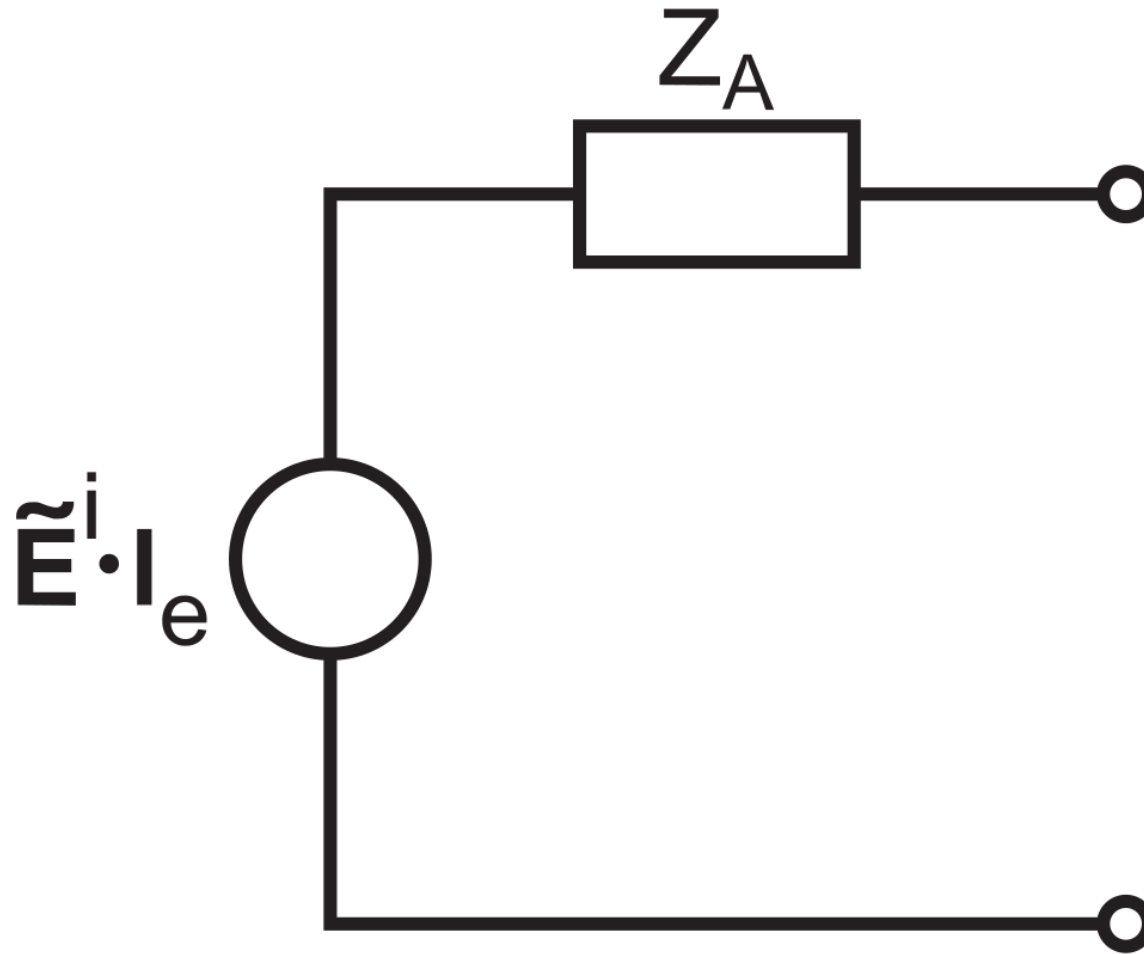


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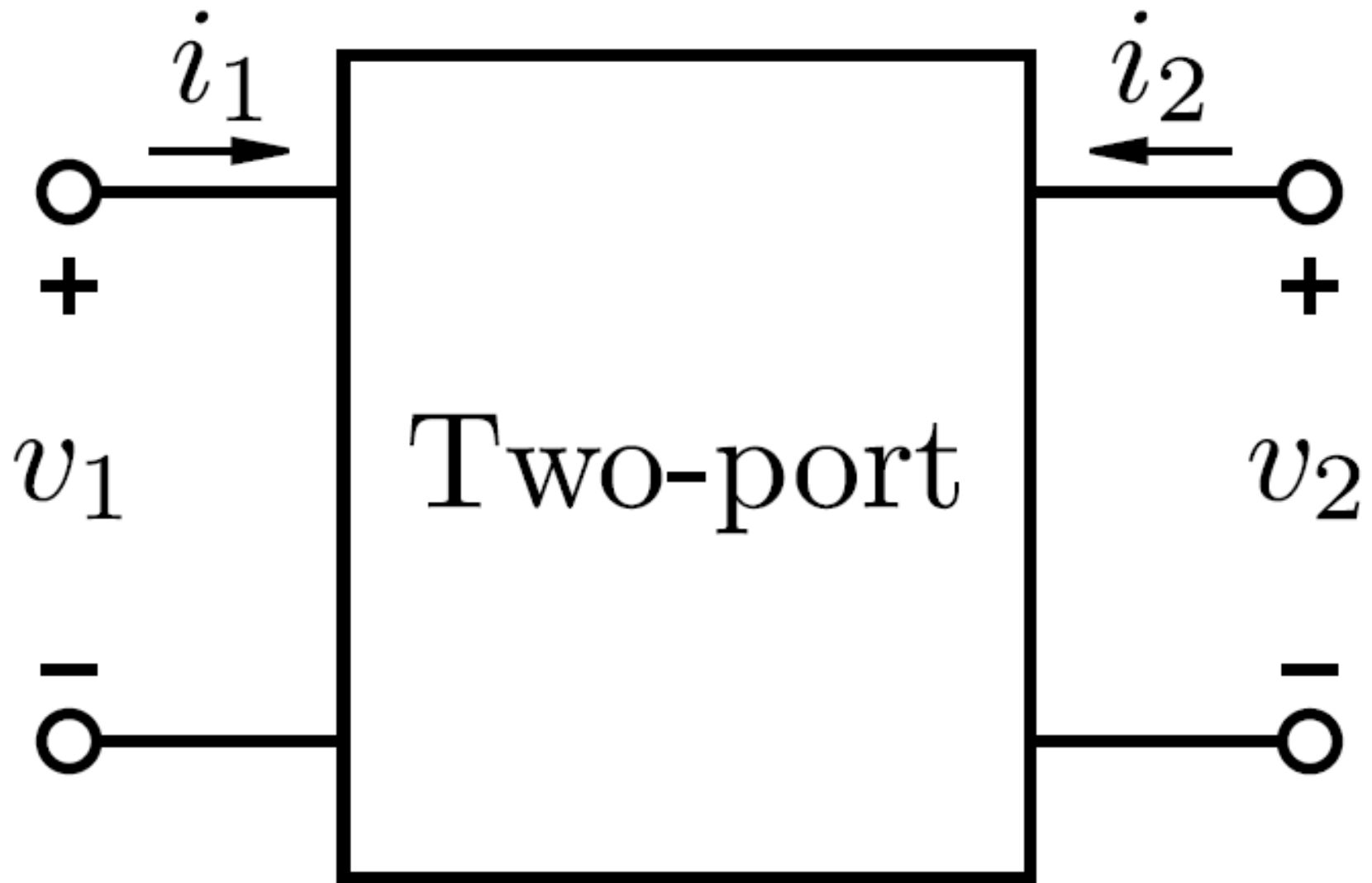


Fig. 10.19: Inductiveload, [https://commons.wikimedia.org/wiki/File:Two Port Circuit.svg](https://commons.wikimedia.org/wiki/File:Two_Port_Circuit.svg), public domain. Modified.

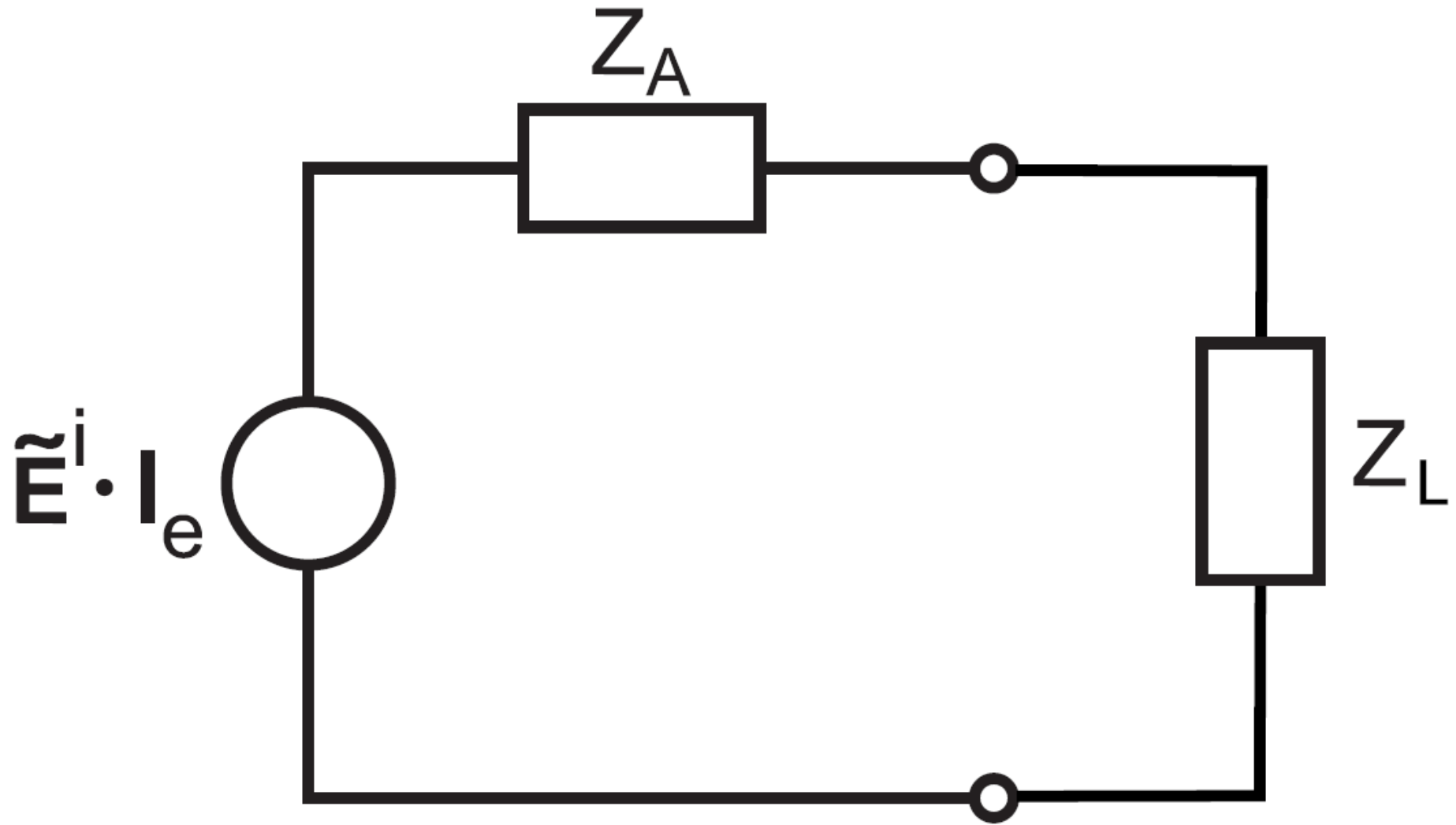


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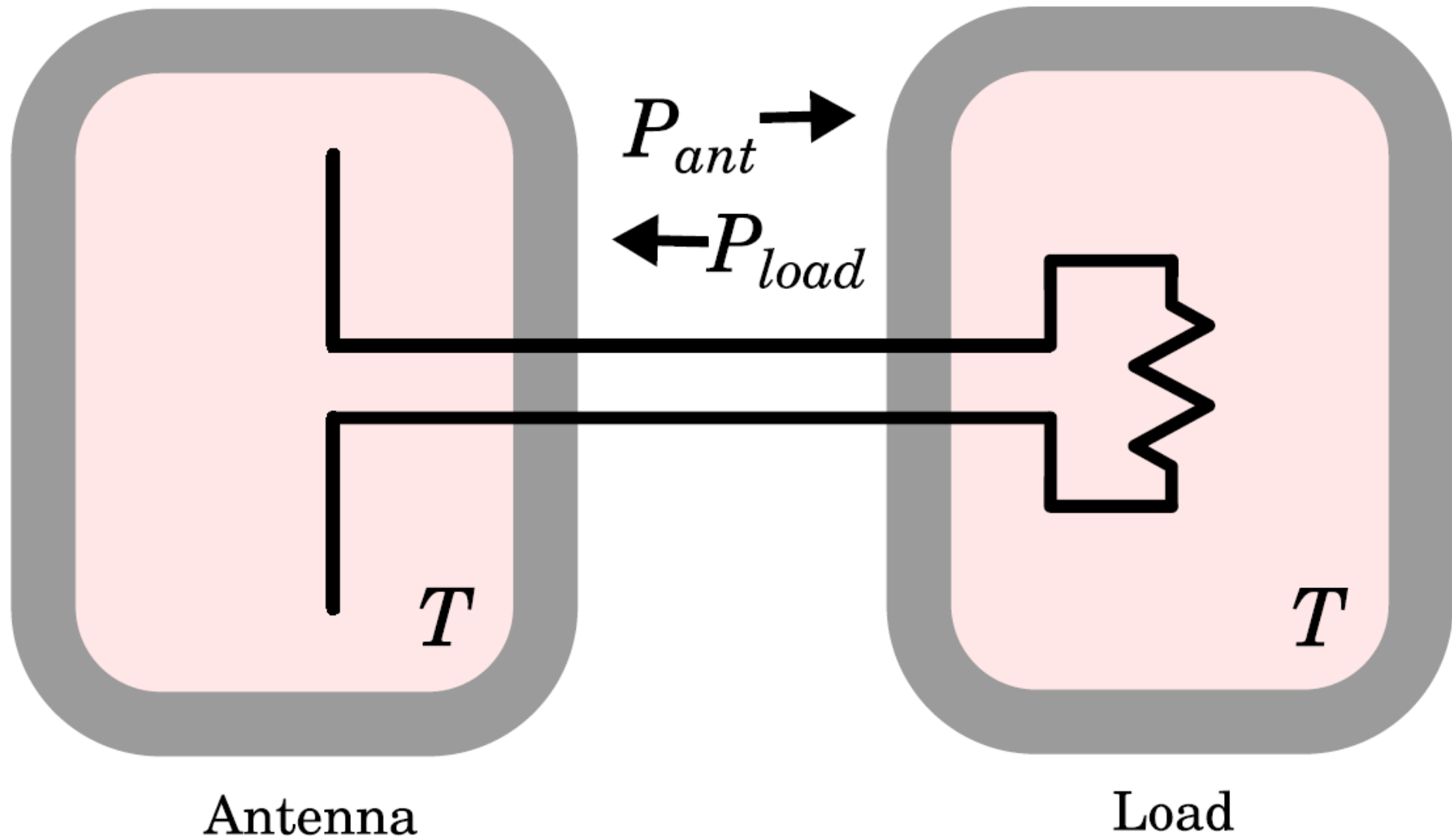


Fig. 10.21: Chetvorno, [https://en.wikipedia.org/wiki/File:Antenna\\_and\\_resistor\\_in\\_cavity.svg](https://en.wikipedia.org/wiki/File:Antenna_and_resistor_in_cavity.svg), public domain. Modified.

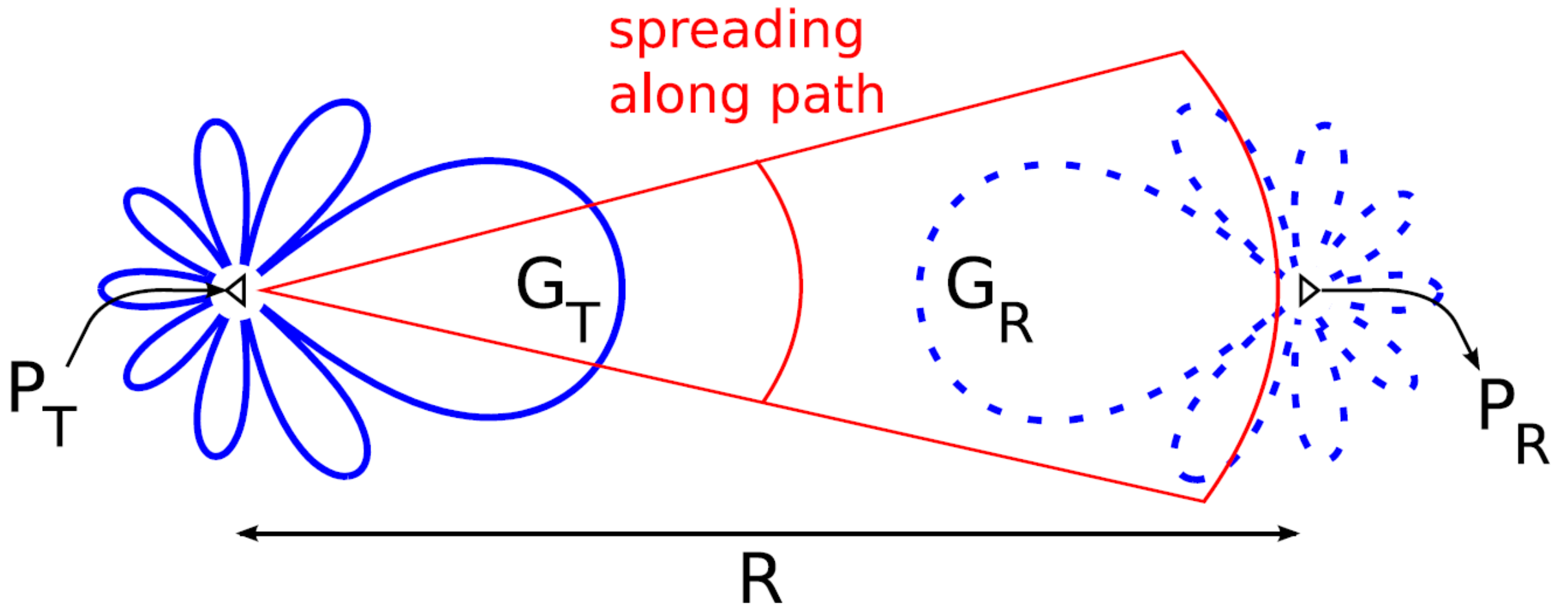


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