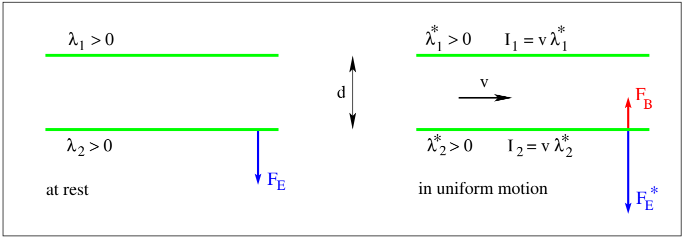
Is There Absolute Motion?

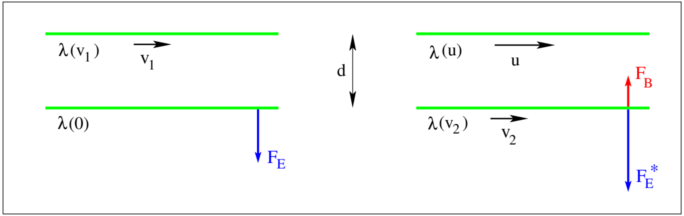
Forces between two long, parallel, charged rods



- $\frac{F_E}{L} = \frac{1}{2\pi\epsilon_0}\frac{\lambda_1\lambda_2}{d}$ (left), $\frac{F_E^*}{L} = \frac{1}{2\pi\epsilon_0}\frac{\lambda_1^*\lambda_2^*}{d}$, $\frac{F_B}{L} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}$, (right)
- $\frac{F_E^* - F_B}{L} = \frac{1}{2\pi\epsilon_0}\frac{\lambda_1^*\lambda_2^*}{d}\left(1 - \frac{v^2}{c^2}\right) = \frac{1}{2\pi\epsilon_0}\frac{\lambda_1\lambda_2}{d}$
- $c = \frac{1}{\sqrt{\epsilon_0\mu_0}} = 2.998 \times 10^8 \text{ms}^{-1}$ (speed of light)
- $\lambda_1^* = \frac{\lambda_1}{\sqrt{1 - v^2/c^2}}$, $\lambda_2^* = \frac{\lambda_2}{\sqrt{1 - v^2/c^2}}$ (due to length contraction)

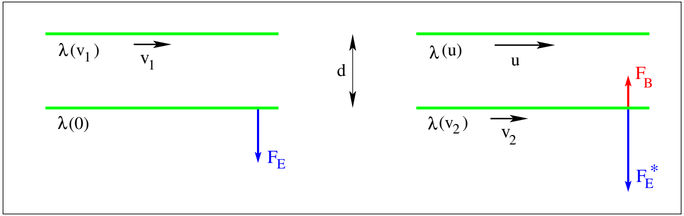
Catching Up with a Photon? (1)

Forces between two long, parallel, charged rods in relative motion.



- Galilean kinematics predicts $u = v_1 + v_2$.
- Relativistic kinematics requires $v_1 < c$, $v_2 < c$, $u < c$.
- Relativistic dynamics requires $F_E^* - F_B = F_E$.
- Length-contracted charge densities: $\lambda(v) = \dfrac{\lambda(0)}{\sqrt{1 - v^2/c^2}}$.
- Electric currents: $I(v) = \lambda(v)v$.

Catching Up with a Photon? (2)



- $\dfrac{F_E}{L} = \dfrac{1}{2\pi\epsilon_0}\dfrac{\lambda(0)\lambda(v_1)}{d}, \qquad \dfrac{F_E^*}{L} = \dfrac{1}{2\pi\epsilon_0}\dfrac{\lambda(v_2)\lambda(u)}{d}.$
- $\dfrac{F_B}{L} = \dfrac{\mu_0}{2\pi}\dfrac{[\lambda(v_2)v_2][\lambda(u)u]}{d} = \dfrac{1}{2\pi\epsilon_0}\dfrac{\lambda(v_2)\lambda(u)}{d}\dfrac{v_2 u}{c^2}.$
- $\dfrac{F_E^* - F_B}{L} = \dfrac{F_E}{L} \quad \Rightarrow \dfrac{1}{2\pi\epsilon_0}\dfrac{\lambda(v_2)\lambda(u)}{d}\left(1 - \dfrac{v_2 u}{c^2}\right) = \dfrac{1}{2\pi\epsilon_0}\dfrac{\lambda(0)\lambda(v_1)}{d}$
- $\Rightarrow \dfrac{1}{\sqrt{1 - v_2^2 c^2}}\dfrac{1}{\sqrt{1 - u^2/c^2}}\left(1 - \dfrac{v_2 u}{c^2}\right) = \dfrac{1}{\sqrt{1 - v_1^2/c^2}}$ to be solved for u.
- Relativistic kinematics predicts $u = \dfrac{v_1 + v_2}{1 + v_1 v_2/c^2} < c.$

Out of Africa

Four friends wish to cross a river at night on a narrow and treacherous bridge.

They have one flashlight.

To walk across the bridge it takes

- Gougouma 1minute,
- Ndakta 2 minutes,
- Maïtaïna 5 minutes,
- Kaïssebo 10 minutes.

The bridge supports not more than two persons simultaneously.

The use of the flashlight is essential on every trip across the bridge.

The duration of any trip is dictated by the slower person.

Describe the sequence of trips that minimizes the total time for the four friends to make it to the other side of the river.