Title: Quantum principle of relativity

Speakers: Andrzej Dragan

Collection: Indefinite Causal Structure

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Composing Causal Structures

Aleks Kissinger

Indefinite Causal Structures
Perimeter Institute 2019

Quantum principle of relativity

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Crash course on special relativity

$$x' = A(V)\,x + B(V)\,t,$$

$$x = A(-V)\,x' + B(-V)\,t'$$

Crash course on special relativity

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$$x' = 0 \qquad x = Vt \qquad \frac{B(V)}{A(V)} = -V$$

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$$x' = A(V)(x - Vt),$$

$$t' = A(V)\left(t - \frac{A(V)A(-V) - 1}{V^2 A(V)A(-V)} Vx\right).$$

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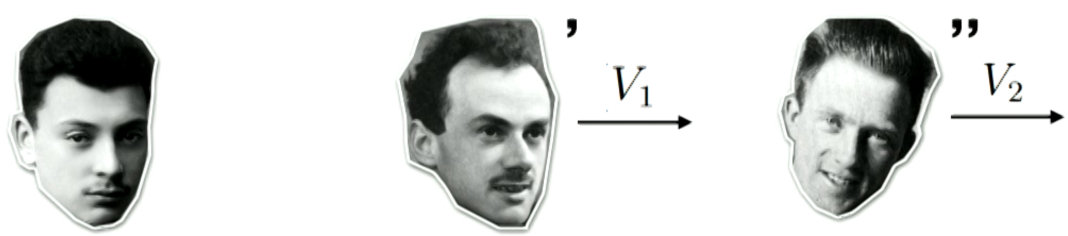

$$
\begin{aligned}
x'' &= A(V_1)A(V_2)x\left(1 + V_1V_2\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)}\right) \\
&\quad -A(V_1)A(V_2)(V_1+V_2)t.
\end{aligned}
$$

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$$

$$
V = \frac{V_1+V_2}{1+V_1V_2\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)}}.
$$

$$x'' = A(V_1)A(V_2)x\left(1 + V_1V_2\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)}\right)$$
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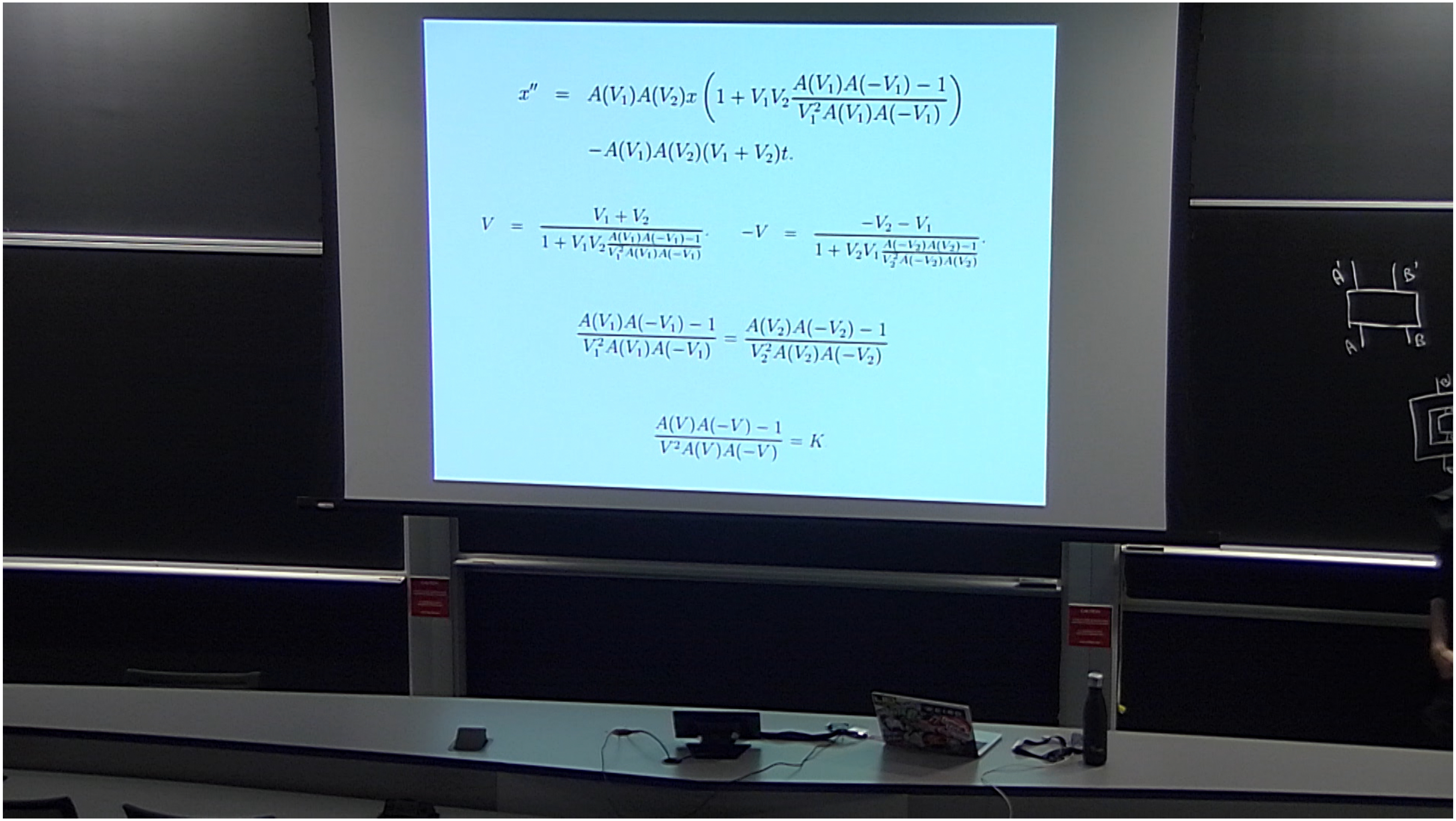
$$\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)} = \frac{A(V_2)A(-V_2)-1}{V_2^2A(V_2)A(-V_2)}$$



$x'' = A(V_1)A(V_2)x\left(1 + V_1V_2\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)}\right)$
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$\frac{A(V)A(-V)-1}{V^2A(V)A(-V)} = K$
A'
B'
A
B

$$x'' = A(V_1)A(V_2)x\left(1 + V_1V_2\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)}\right)$$
$$-A(V_1)A(V_2)(V_1+V_2)t.$$

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$$\frac{A(V_1)A(-V_1)-1}{V_1^2A(V_1)A(-V_1)} = \frac{A(V_2)A(-V_2)-1}{V_2^2A(V_2)A(-V_2)}$$

$$\frac{A(V)A(-V)-1}{V^2A(V)A(-V)} = K.$$

$$A(-V) = A(V)$$

$$\begin{aligned} x' &= \frac{x - Vt}{\sqrt{1 - KV^2}}, \\ t' &= \frac{t - KVx}{\sqrt{1 - KV^2}}. \end{aligned}$$

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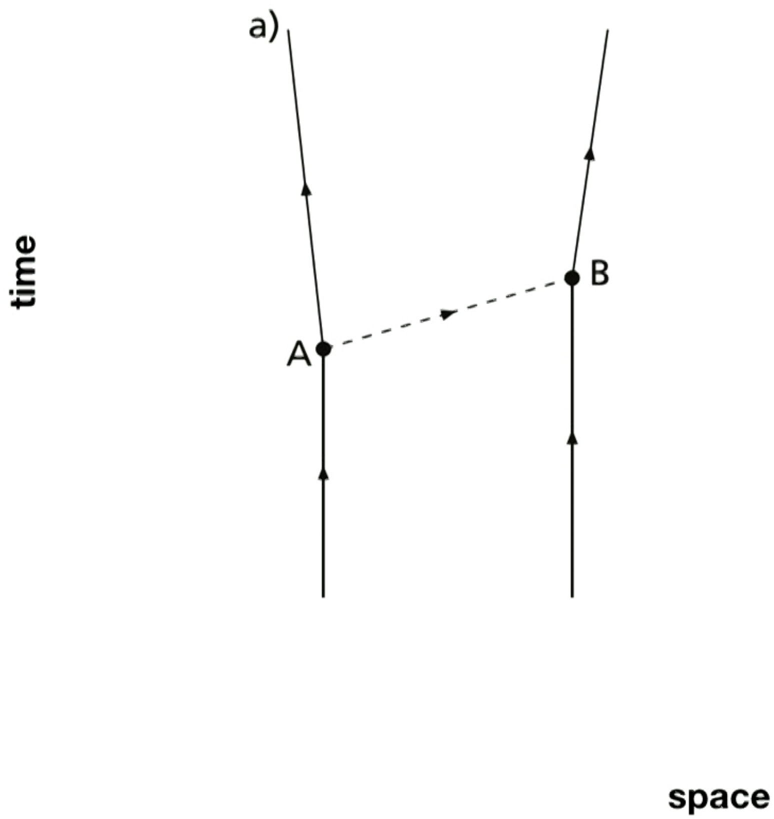
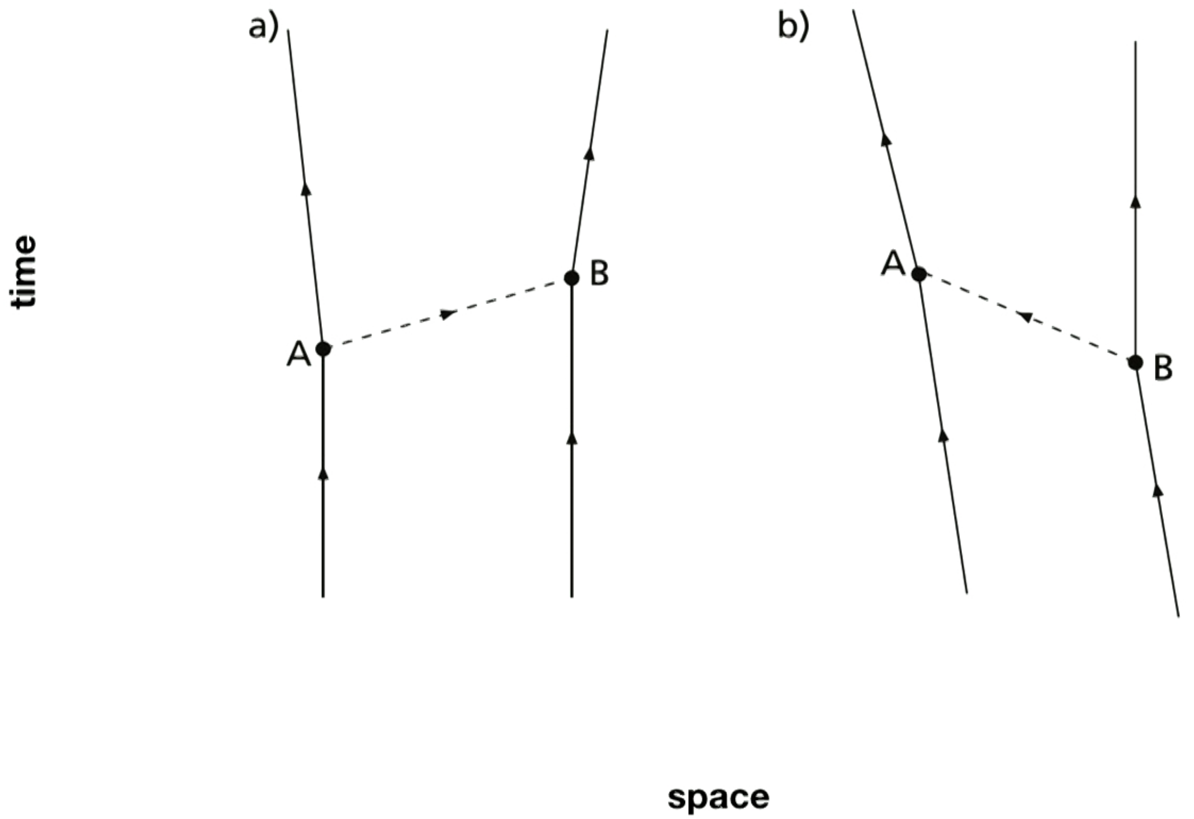
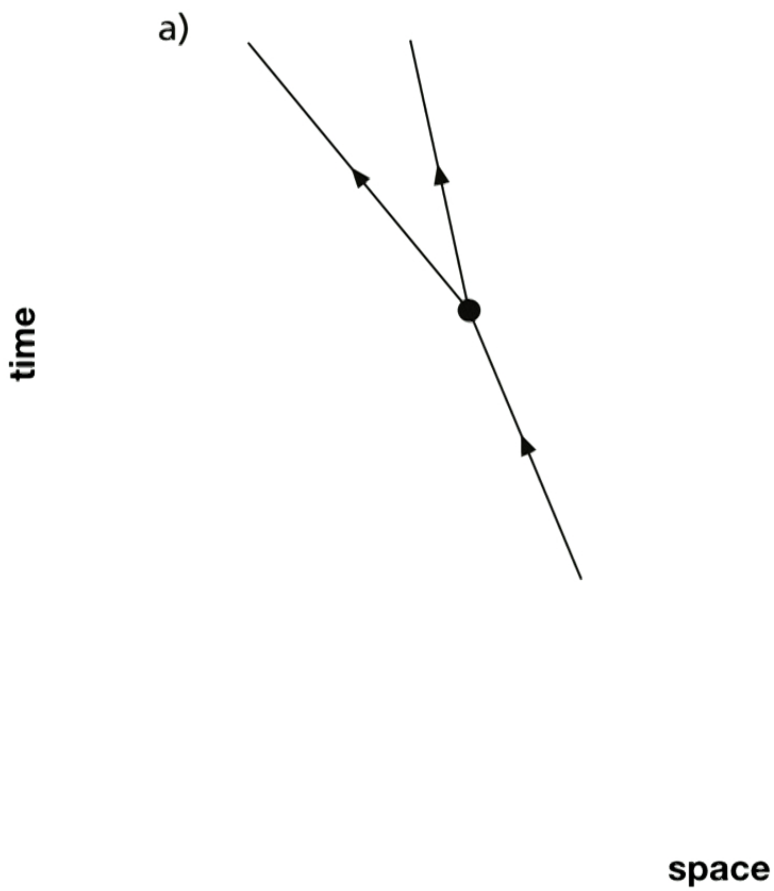
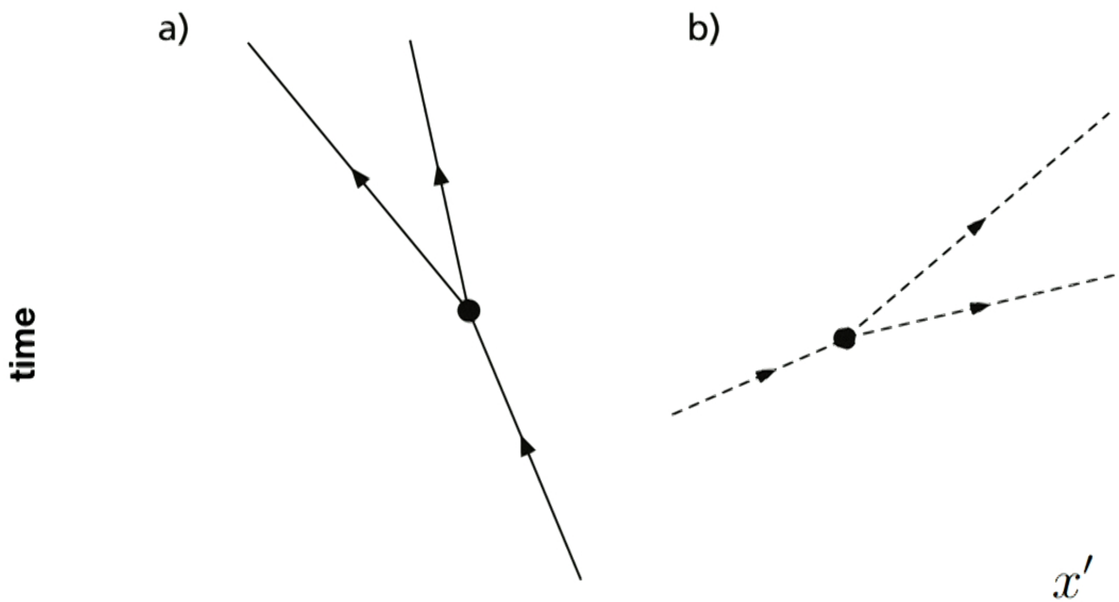
$$A(-V) = -A(V)$$

$$\begin{aligned} x' &= \pm\frac{V}{|V|}\frac{x - Vt}{\sqrt{V^2/c^2 - 1}}, \\ t' &= \pm\frac{V}{|V|}\frac{t - Vx/c^2}{\sqrt{V^2/c^2 - 1}}. \end{aligned}$$


a)
B
A
time
space


a)
A
B
b)
A
B
time
space

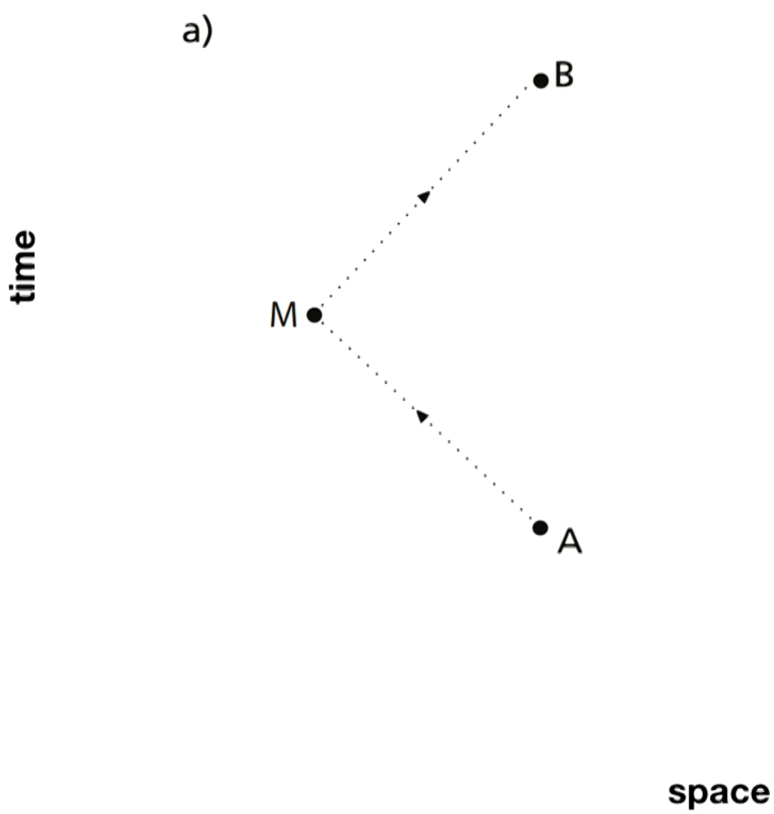

a)
time
space

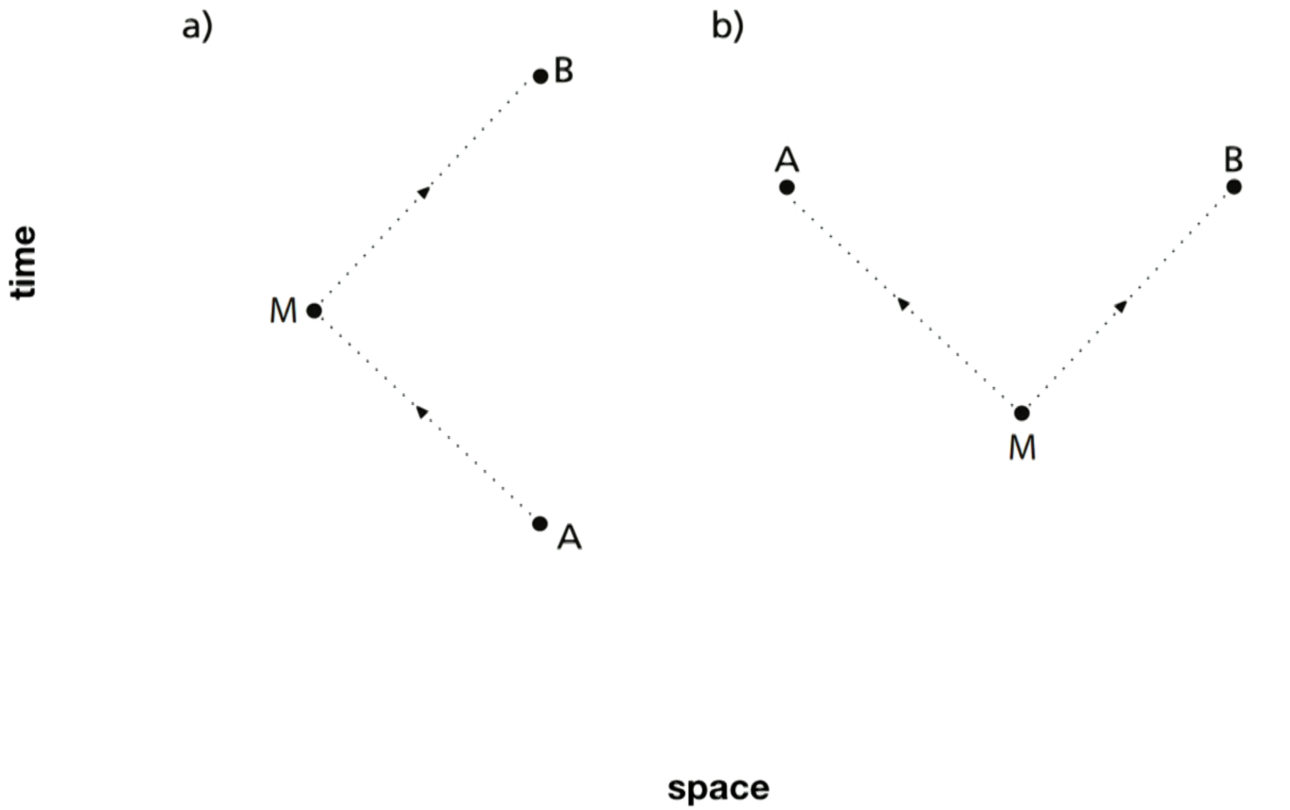


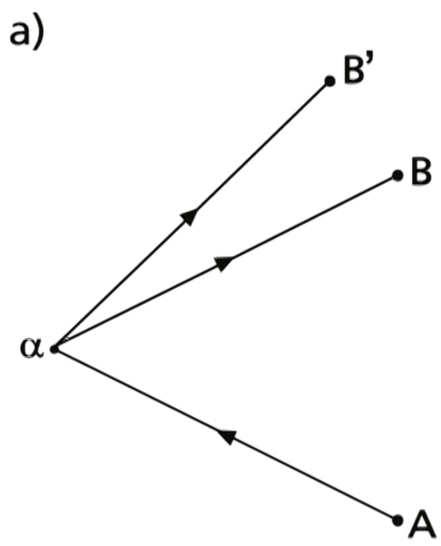
$$x' = ct,$$

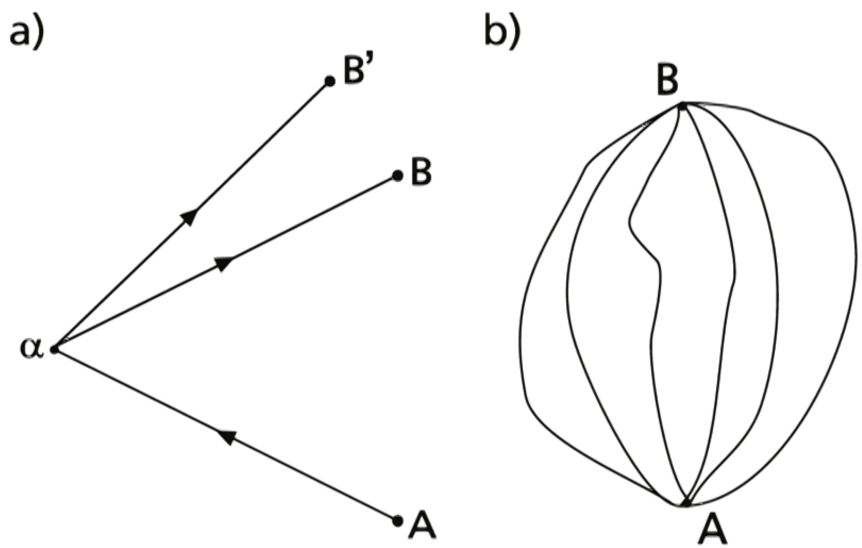
$$ct' = x.$$

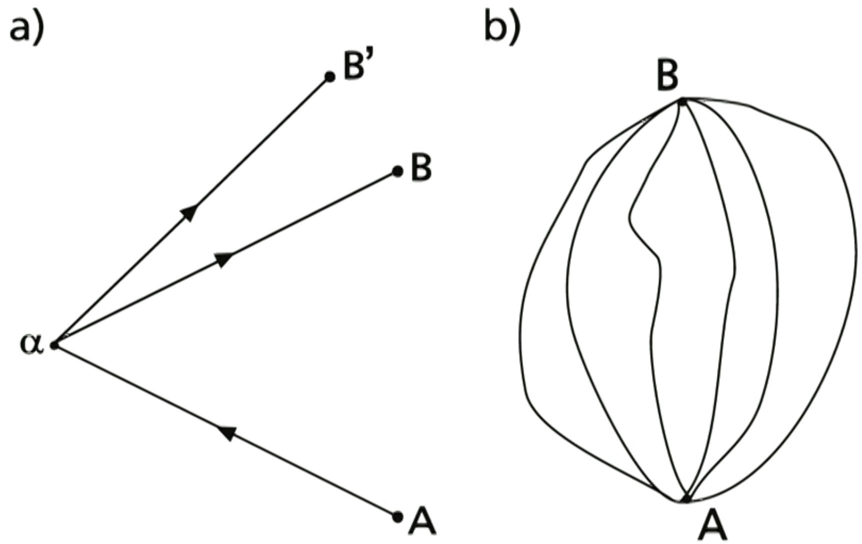
space


a)
B
M
A
time
space

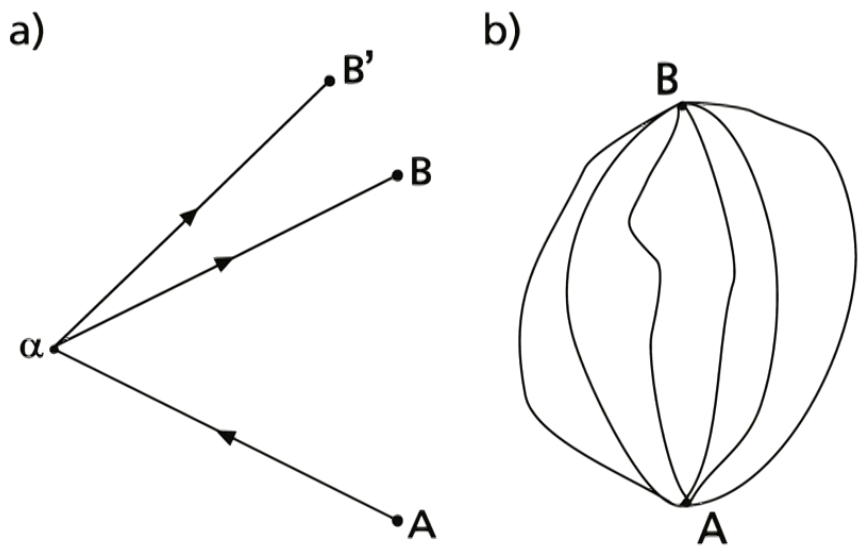

a)
b)
B
A
M
time
space


a)
B'
B
α
A


a)
B'
B
α
A
b)
B
A



$$\phi \sim \int_{\mathsf{A}}^{\mathsf{B}} \sqrt{1 - v^2/c^2}\,\mathrm{d}t$$



$$\phi \sim \int_{\mathsf{A}}^{\mathsf{B}} \sqrt{1 - v^2/c^2}\,\mathrm{d}t \sim \int_{\mathsf{A}}^{\mathsf{B}} (E\,\mathrm{d}t - p\,\mathrm{d}x)$$

$$E \sim \frac{1}{\sqrt{1-v^2/c^2}} \qquad p \sim \frac{v}{\sqrt{1-v^2/c^2}}$$

$$\mathcal{P}^{(n)}(\phi_1, \phi_2, \ldots, \phi_n) = \mathcal{P}^{(n)}(\phi_{\pi(1)}, \phi_{\pi(2)}, \ldots, \phi_{\pi(n)})$$

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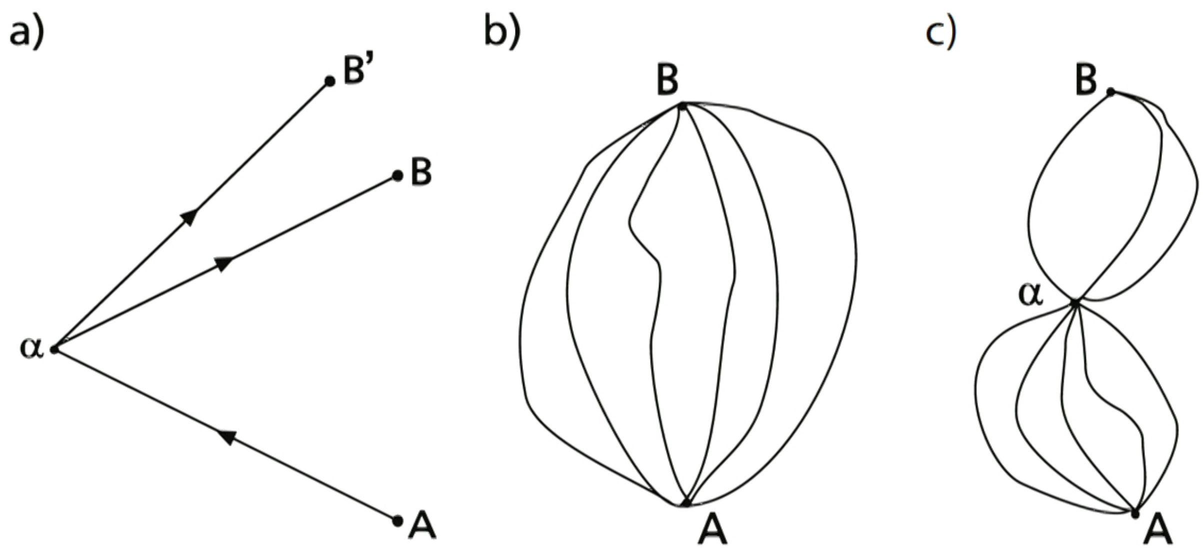

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$$\mathcal{P}^{(nm)}(\phi_1 + \xi_1, \phi_1 + \xi_2, \phi_1 + \xi_3, \ldots, \phi_n + \xi_m) = \mathcal{P}^{(n)}(\phi_1, \phi_2, \ldots, \phi_n)\mathcal{P}^{(m)}(\xi_1, \xi_2, \ldots, \xi_m)$$

$$\mathcal{P}^{(n)}(\phi_1, \phi_2, \ldots, \phi_n) = \mathcal{P}^{(n)}(\phi_{\pi(1)}, \phi_{\pi(2)}, \ldots, \phi_{\pi(n)})$$

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$$\mathcal{P}^{(n)}(\phi_1, \phi_2, \ldots, \phi_n) = \frac{1}{n^\beta}\left(e^{\alpha\phi_1} + e^{\alpha\phi_2} + \ldots + e^{\alpha\phi_n}\right)^\gamma \left(e^{-\alpha\phi_1} + e^{-\alpha\phi_2} + \ldots + e^{-\alpha\phi_n}\right)^\gamma$$

Thank you