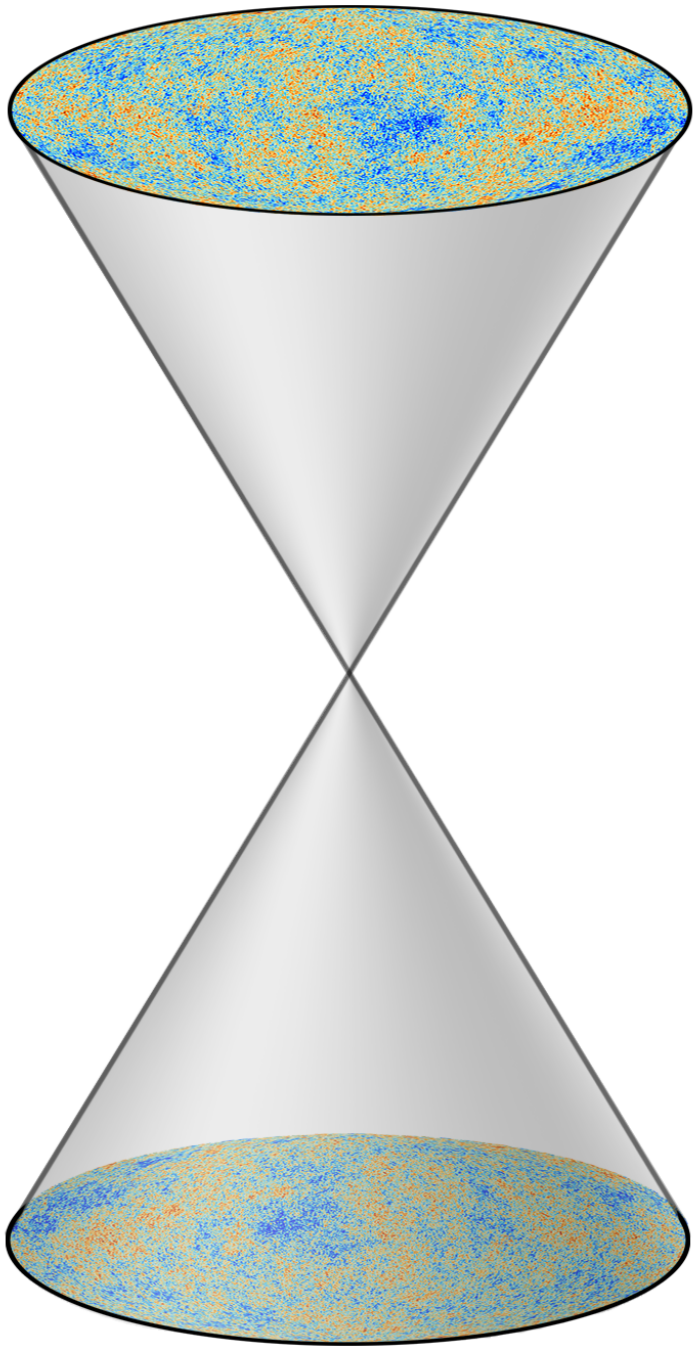
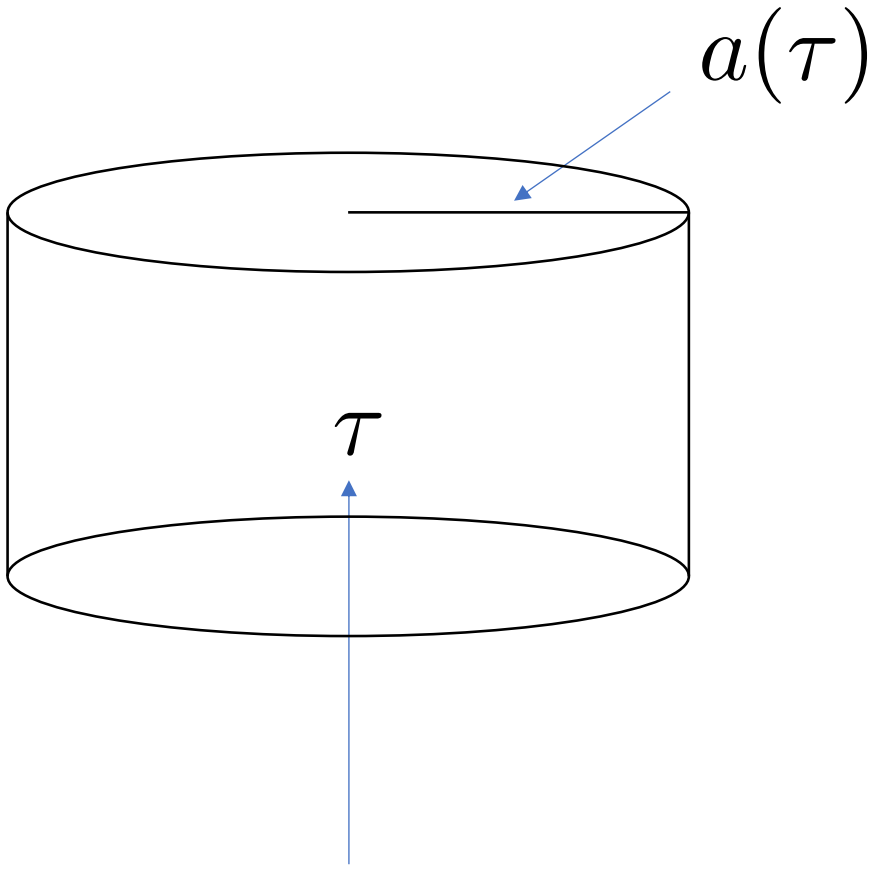
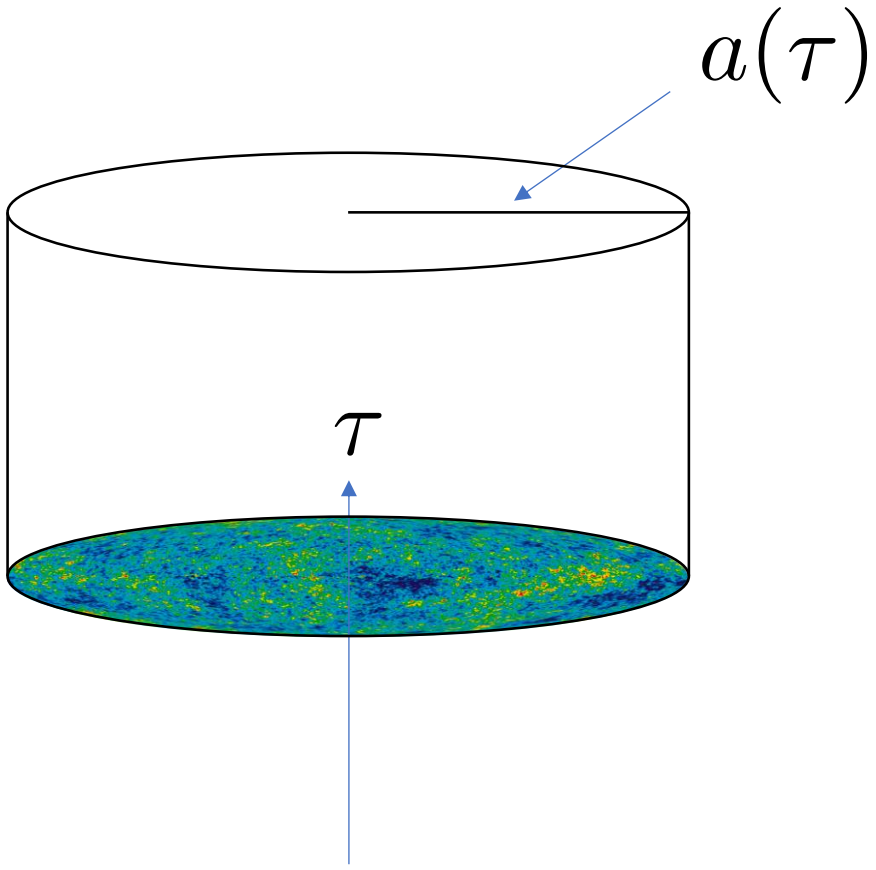


CPT-Symmetric Universe

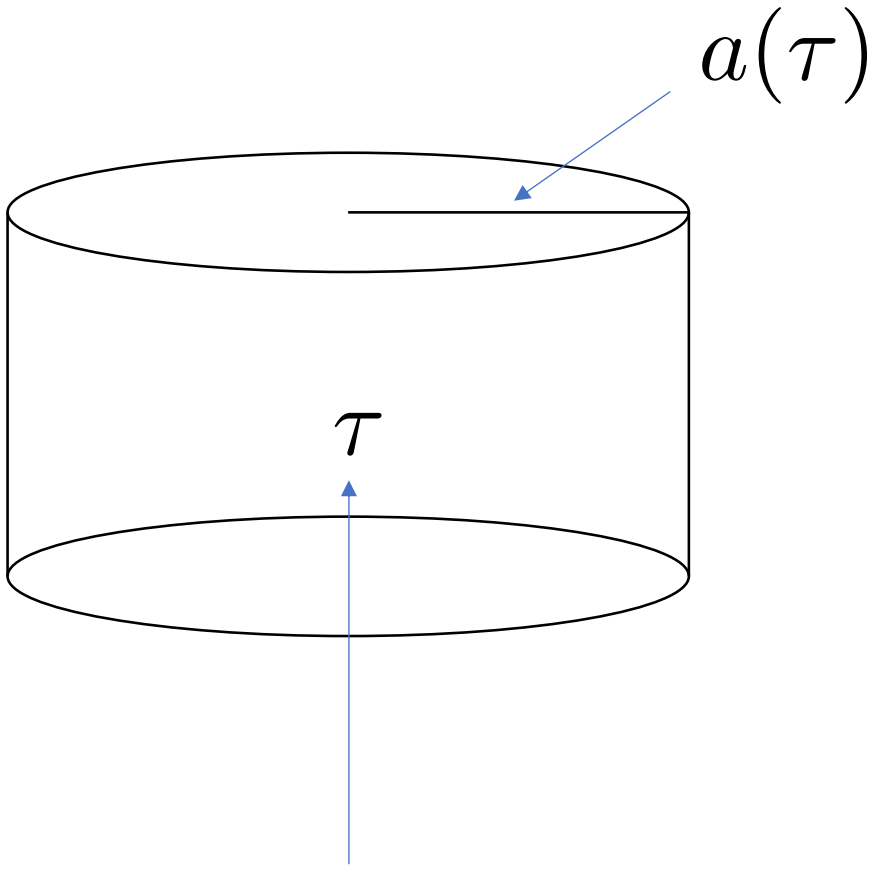
Latham Boyle (Perimeter Institute)

Based on:
arXiv:01803.08930 and arXiv:1803.08928 (PRL 2018)
(with Kieran Finn and Neil Turok)


$a(\tau)$
τ


$a(\tau)$
τ

$$g_{\mu\nu} = a^2(\tau)\eta_{\mu\nu}$$



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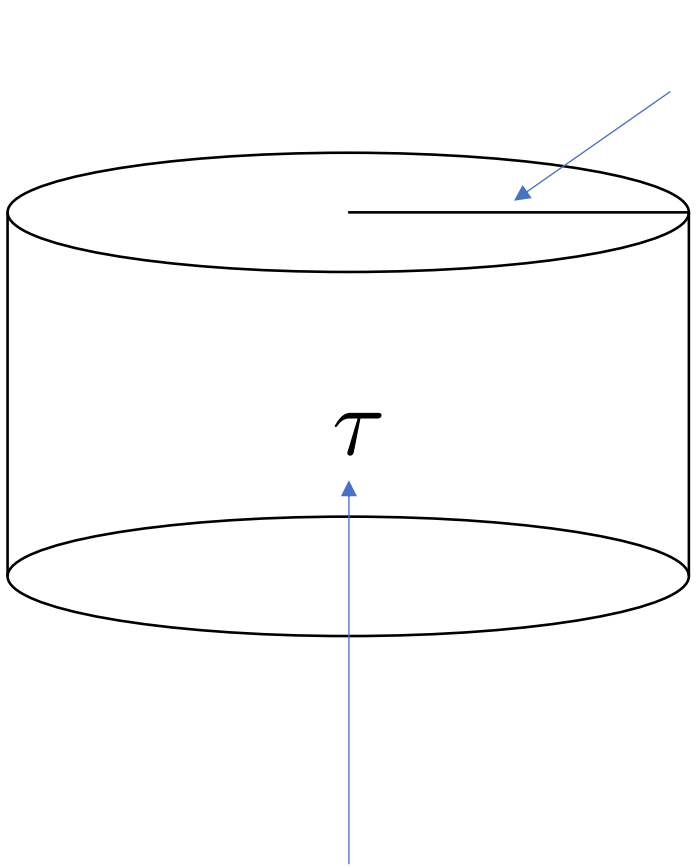
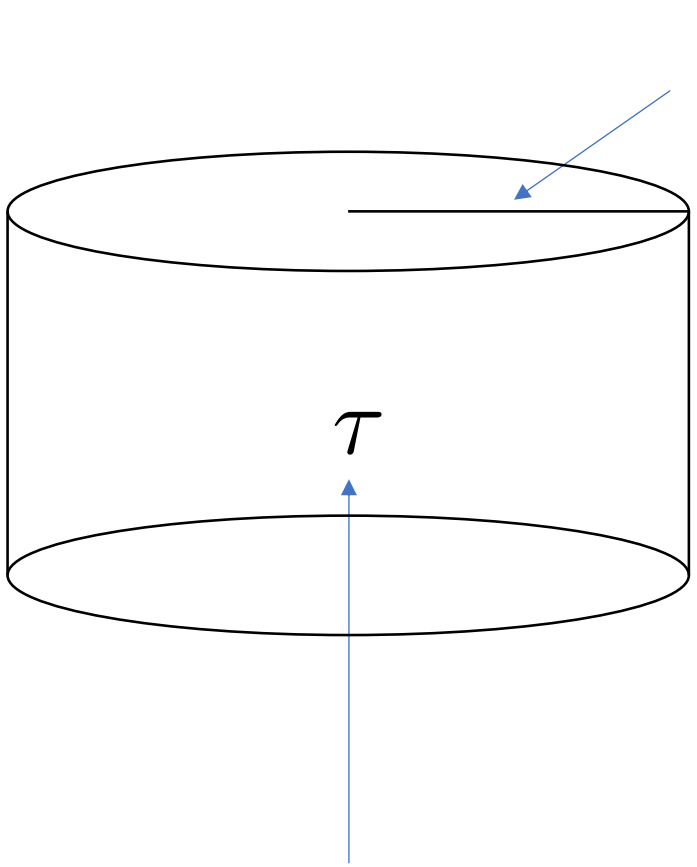


$$a(\tau) \propto \tau$$

$$g_{\mu\nu} = a^2(\tau)\eta_{\mu\nu}$$

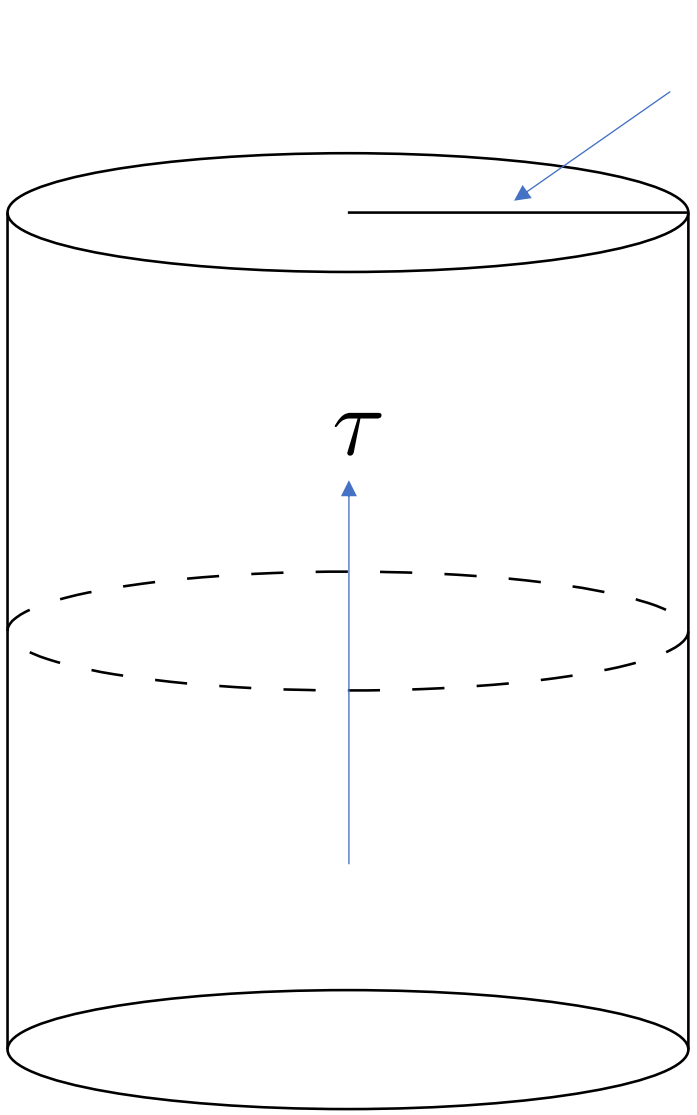


$$a(\tau) \propto \tau$$

new isometry:

$$\tau \rightarrow -\tau$$

$$g_{\mu\nu} = a^2(\tau)\eta_{\mu\nu}$$



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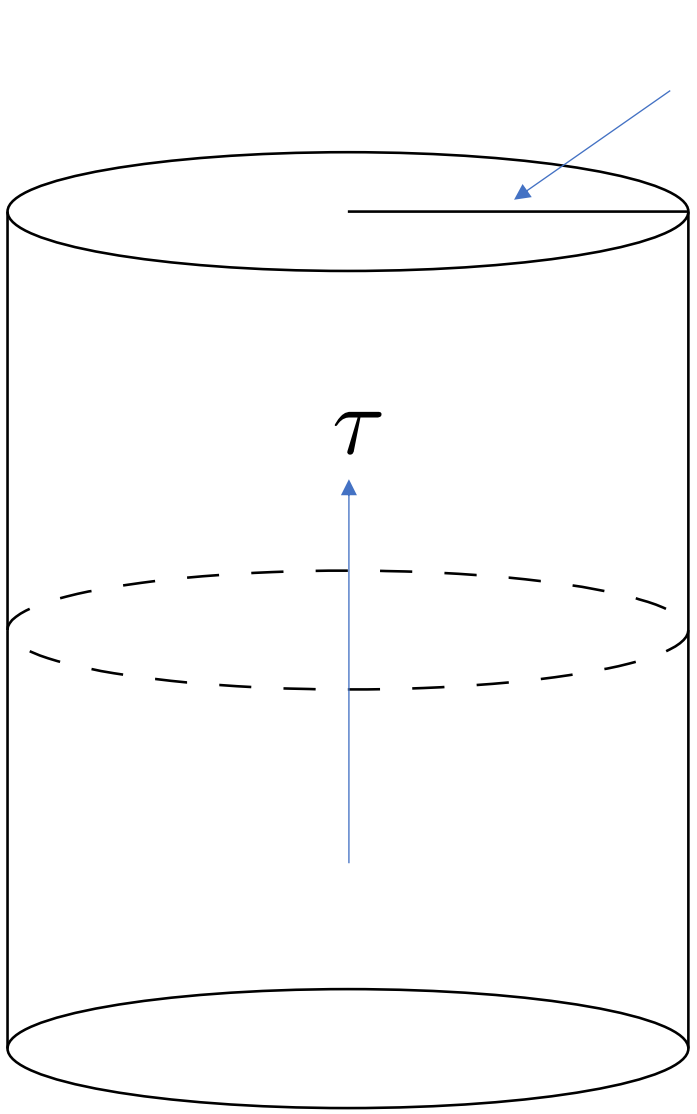

$a(\tau) \propto \tau$

new isometry:

$\tau \to -\tau$

preferred vacuum:

$|0_{CPT}\rangle$

Hypothesis: CPT is NOT spontaneously broken

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Tomorrow – new predictions for:

- Dark Matter
- Neutrino Physics
- Primordial Perturbations

Hypothesis: CPT is NOT spontaneously broken

Tomorrow – new predictions for:

- Dark Matter
- Neutrino Physics
- Primordial Perturbations

Today – new perspectives on:

- The Big Bang
- The Arrow of Time

an analogy: pair creation in an electric field

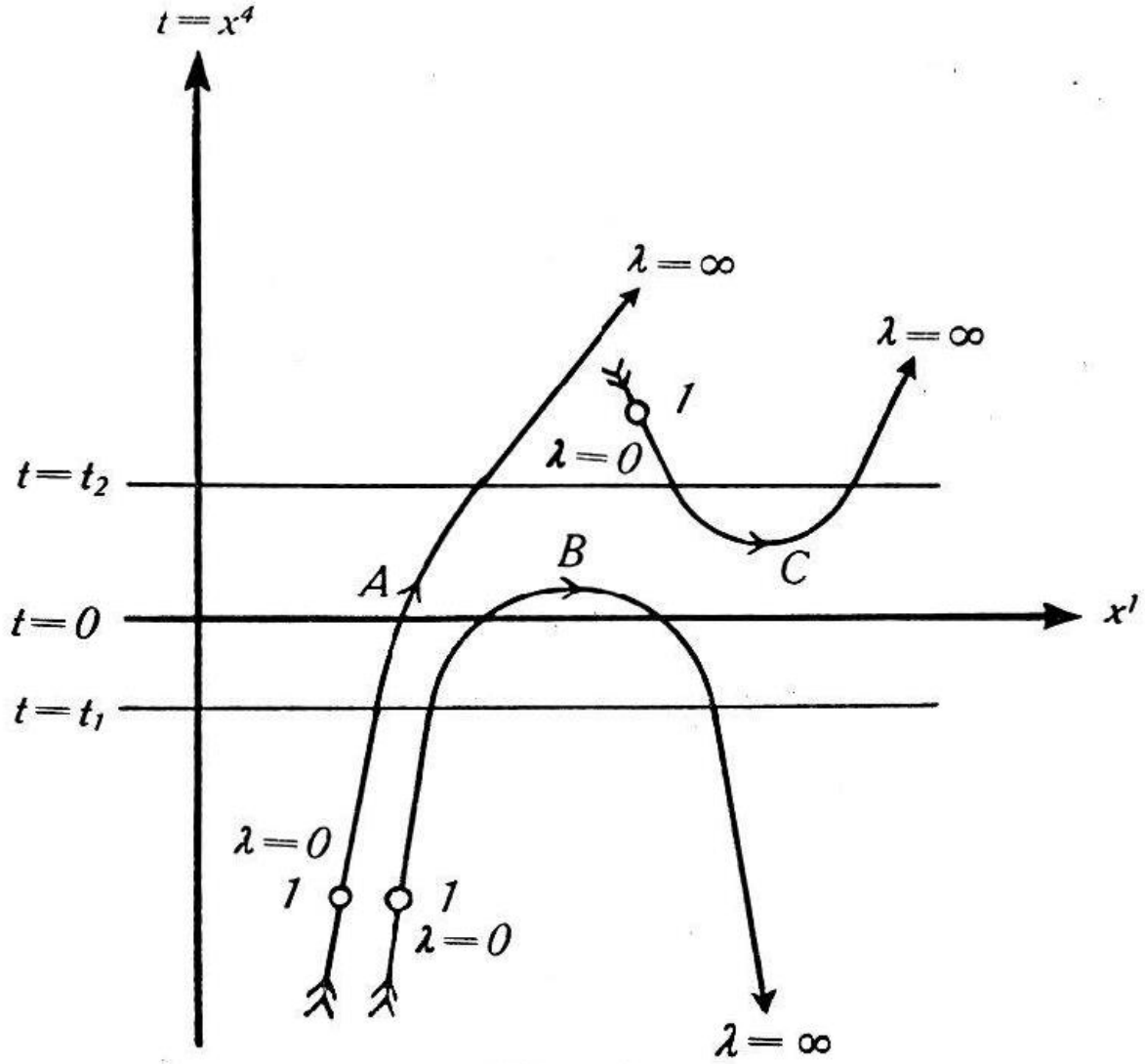
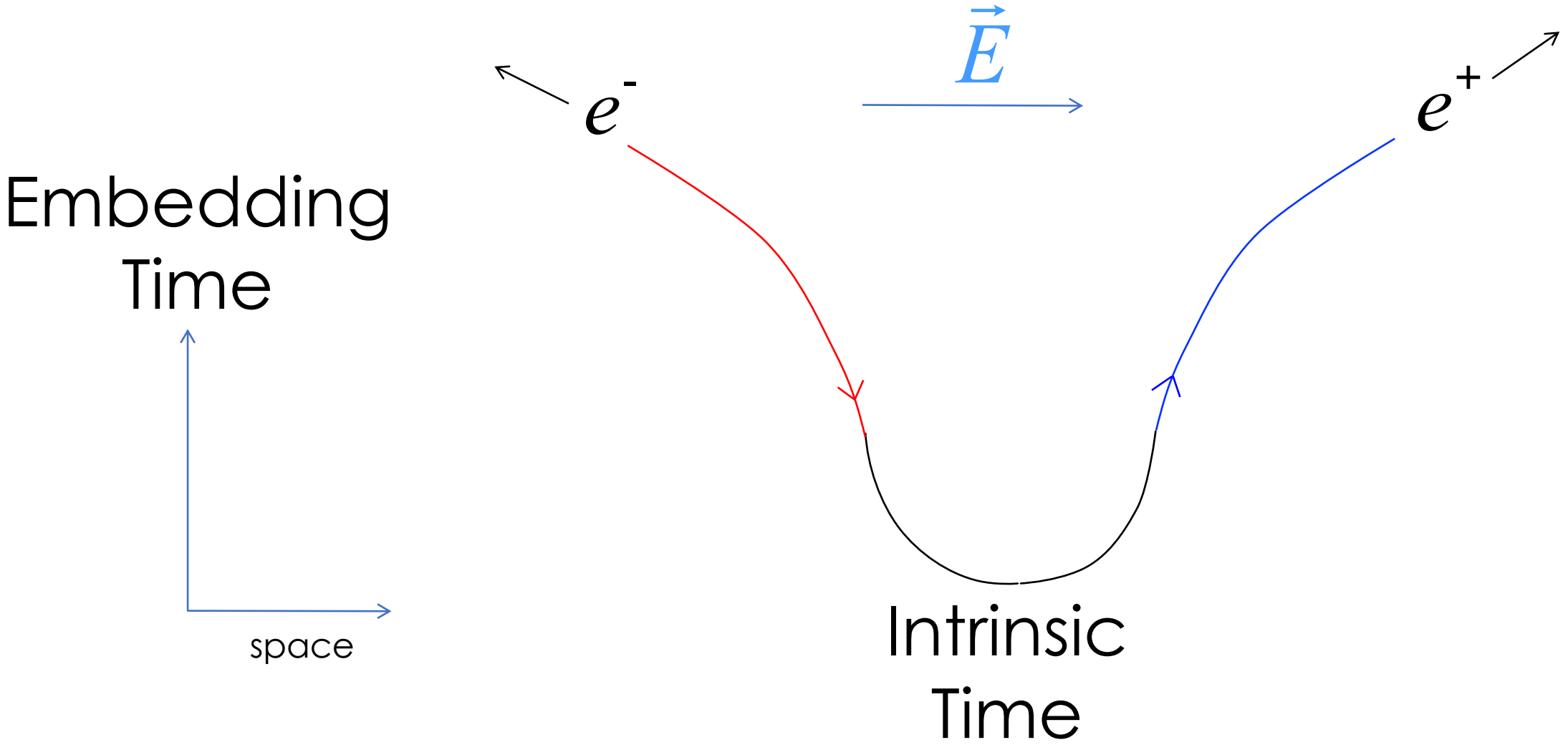
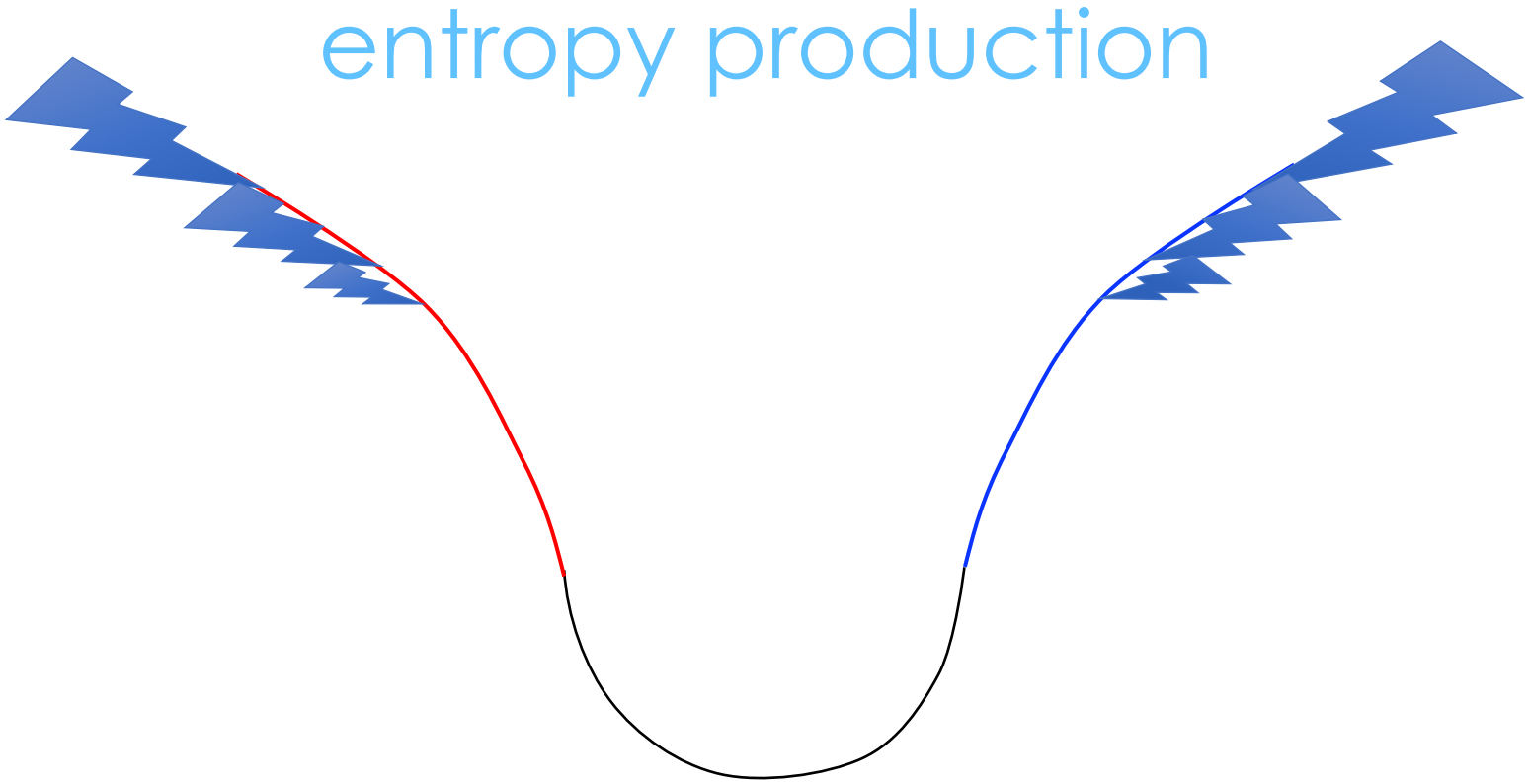


Fig. 1.

Ernst Stueckelberg 1941

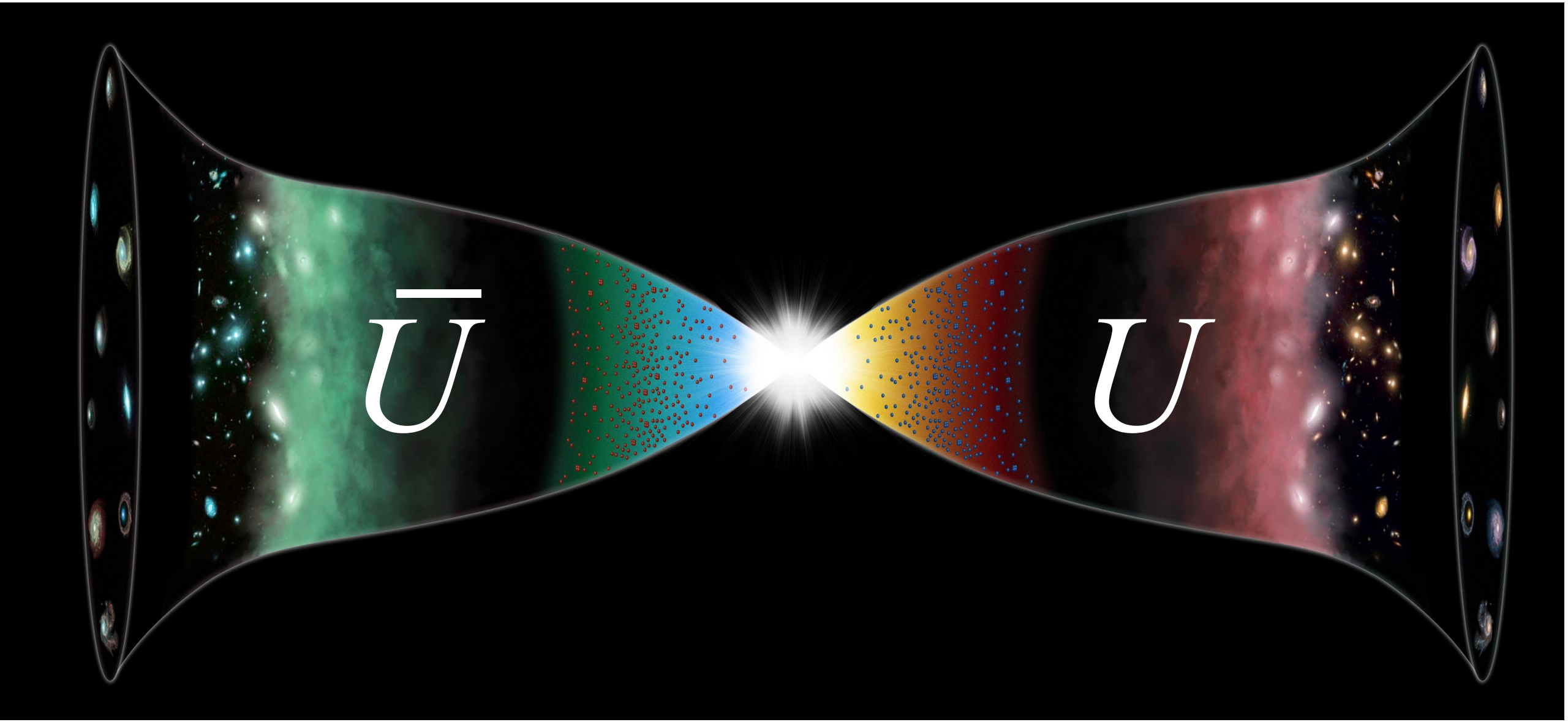

Embedding
Time
space
e^-
$\vec{E}$
e^+
Intrinsic
Time



(EM cascade)

CPT symmetric universe

w/L. Boyle and K. Finn, 1803.08928; 1803.08930
Phys.Rev.Lett. 121 (2018) no.25, 251301



$$a(-t) = -a(t)$$

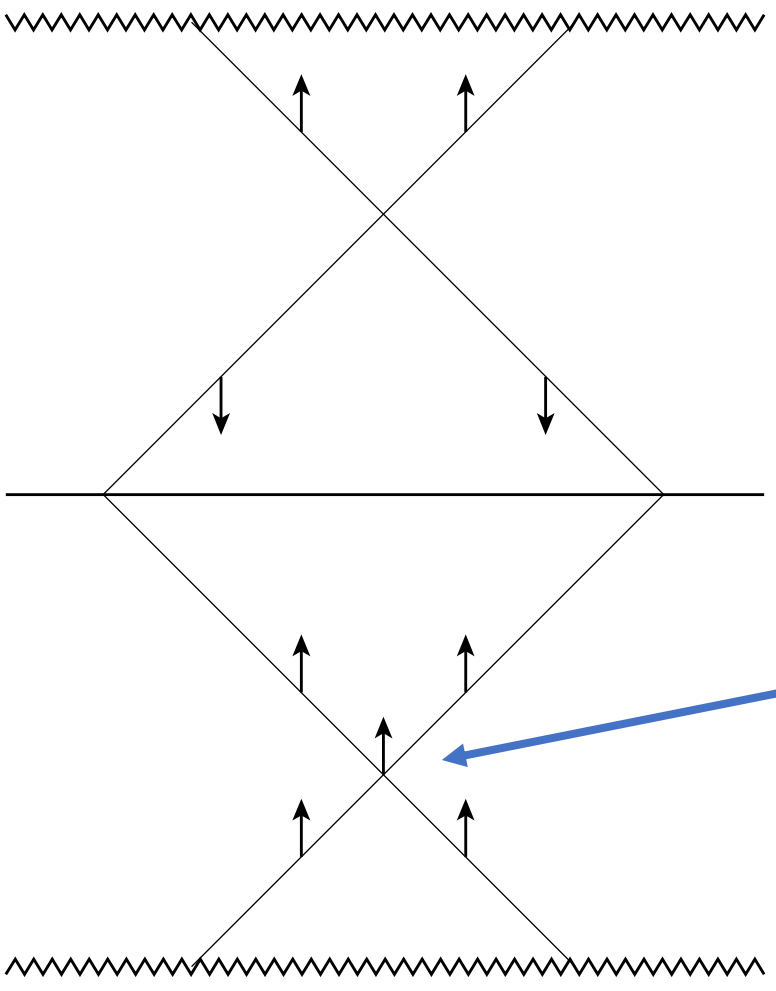
Electrodynamic Arrow of Time

Electrodynamic Arrow of Time

Tetrode-Fokker-Wheeler-Feynman:

$$S = -\sum_a m_a \int da + \sum_{a<b} e_a e_b \int \int da_\mu db^\mu \delta(ab_\nu ab^\nu)$$

Electrodynamic Arrow of Time



Tetrode-Fokker-Wheeler-Feynman:

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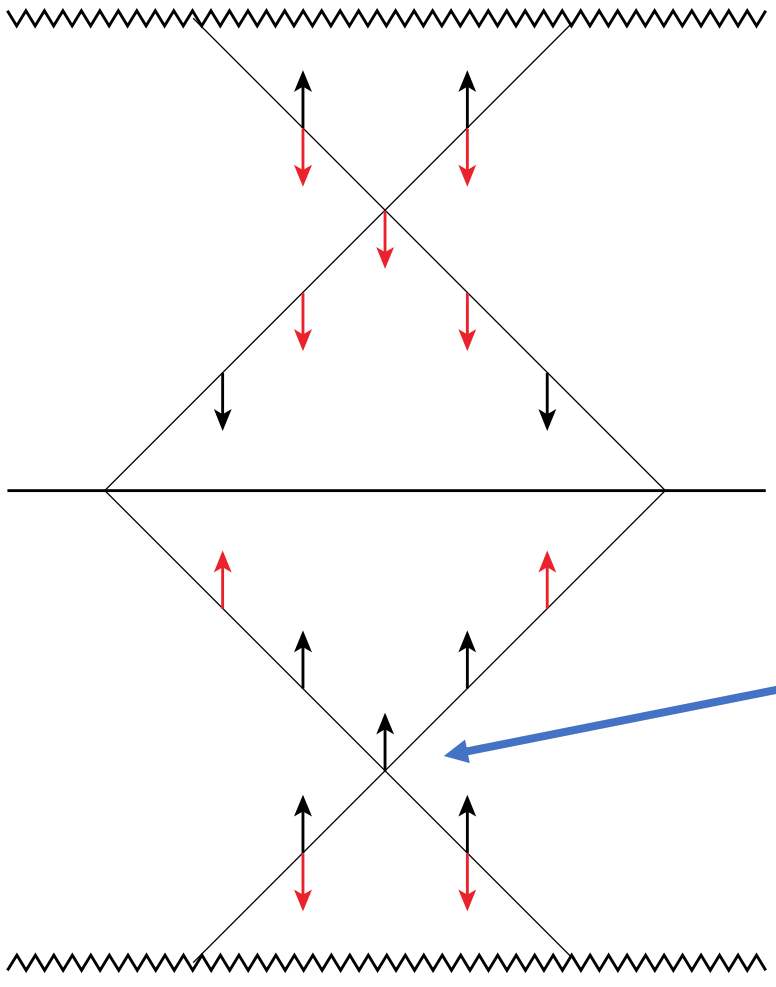
F = (R + A)/2

Electrodynamic Arrow of Time



Tetrode-Fokker-Wheeler-Feynman:

$$S = -\sum_a m_a \int da + \sum_{a<b} e_a e_b \int\int da_\mu db^\mu \delta(ab_\nu ab^\nu)$$

F = (R + A)/2

+ (R – A)/2

Conclusions

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- Hypothesis: CPT is NOT spontaneously violated.

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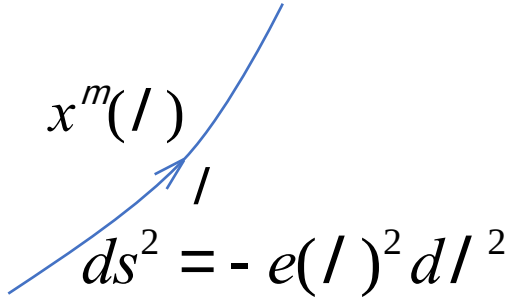
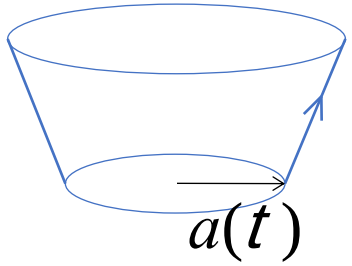
- Tomorrow -- new testable predictions for:
  - Dark Matter
  - Neutrino physics
  - Primordial perturbations

Superspace= space of dynamical coordinates



$$ds^2 = -e(l)^2 dl^2$$

$$S_{particle} \sim \int dl \left(-e^{-1} \left(\frac{dx^0}{dl}\right)^2 + .. \right)$$



$$S_{GR} \sim \int d^4x \left(-N^{-1} \left(\frac{da}{dt}\right)^2 + \ldots \right)$$

$$ds^2 = a(\tau)^2(-d\tau^2 + d\vec{x}^2)$$