McGill

Loop Equations for Gauge/Gravity Duality

JAMES SULLY

B. Czech, L. Lamprou, S.McCandlish, B. Mosk, JS arXiv: 1604.03110

B. Czech, L. Lamprou, S.McCandlish, B. Mosk, JS arXiv: 1608.06282

B. Czech, L. Lamprou, S.McCandlish, JS Ongoing

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  - The CFT lives in **one fewer dimension** than the gravity dual

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- **String theory… or not:**
  - **String theory** is a **well-defined**, UV complete, background-ind. theory.
  - **But gauge/gravity duality is more general**: dual theory **need not be a string theory.** Expect consistent theories of gravity from CFTs that have no string theory description.

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Problem: Less that we can't compute in the CFT, more that we **don't know what to ask.**

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This talk:
Some work that leans in this direction…

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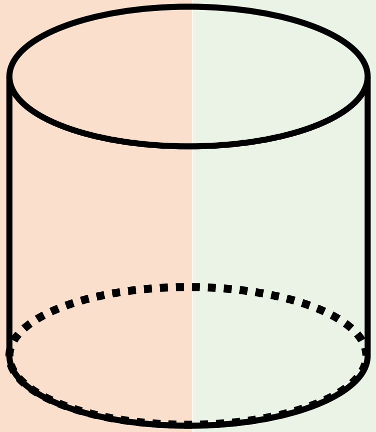

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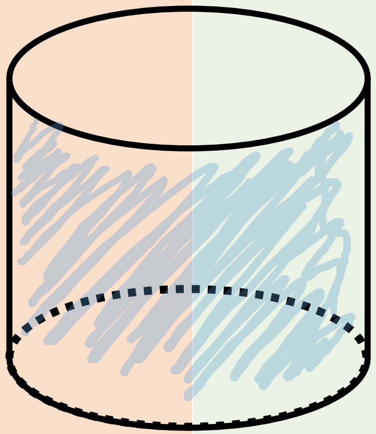

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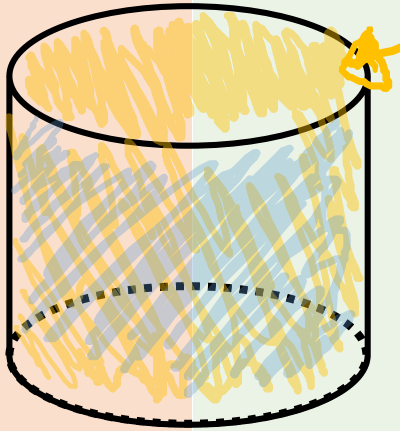

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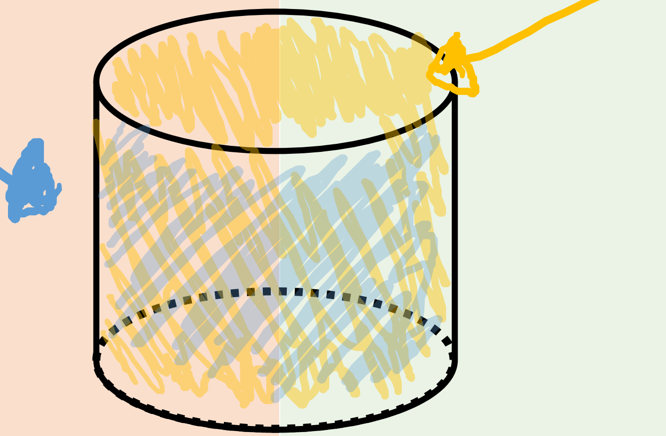

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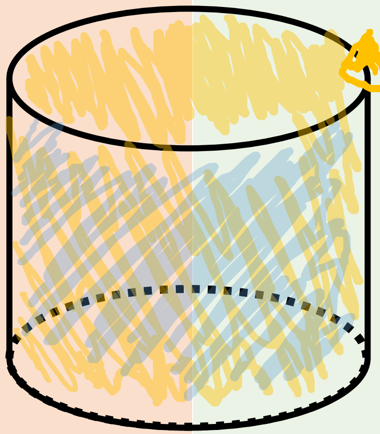

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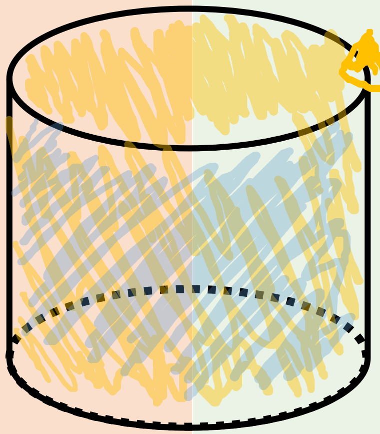

Semiclassical Limit

Generalized Free CFT

Classical geometry, Perturbative gravity

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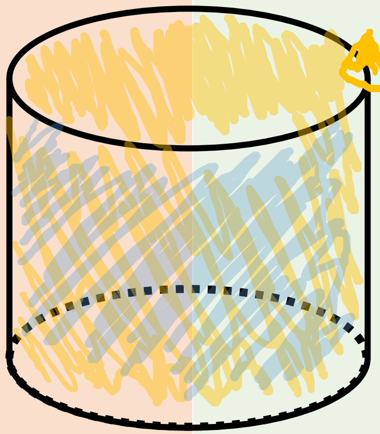

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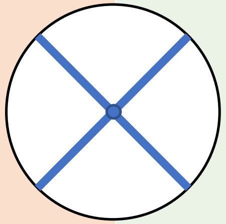
$\langle \mathcal{O}_1 \mathcal{O}_2 \mathcal{O}_3 \mathcal{O}_4 \rangle =$  $= \lim \langle \phi_1 \phi_2 \phi_3 \phi_4 \rangle$

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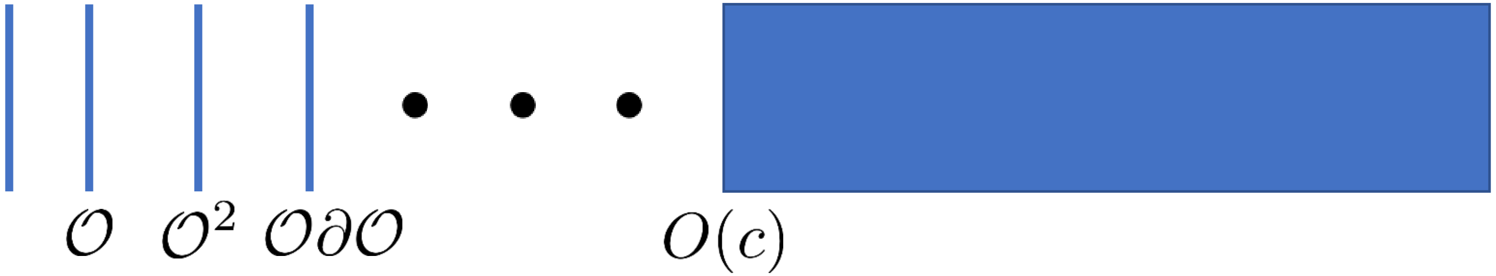

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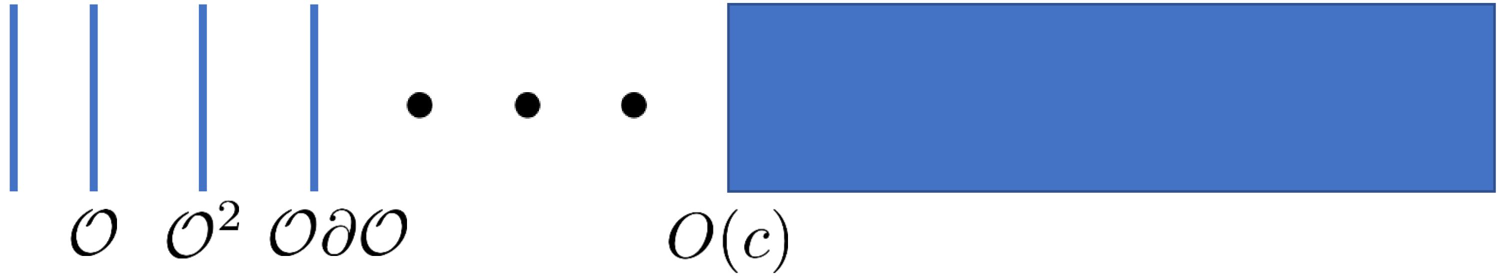

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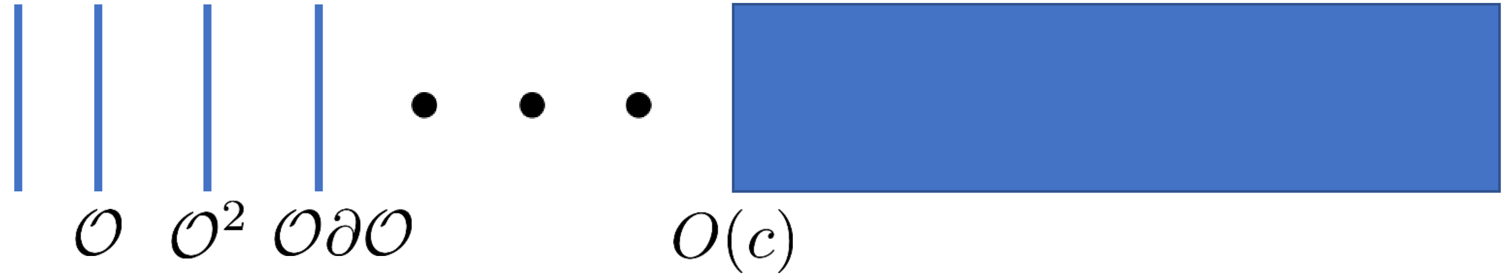

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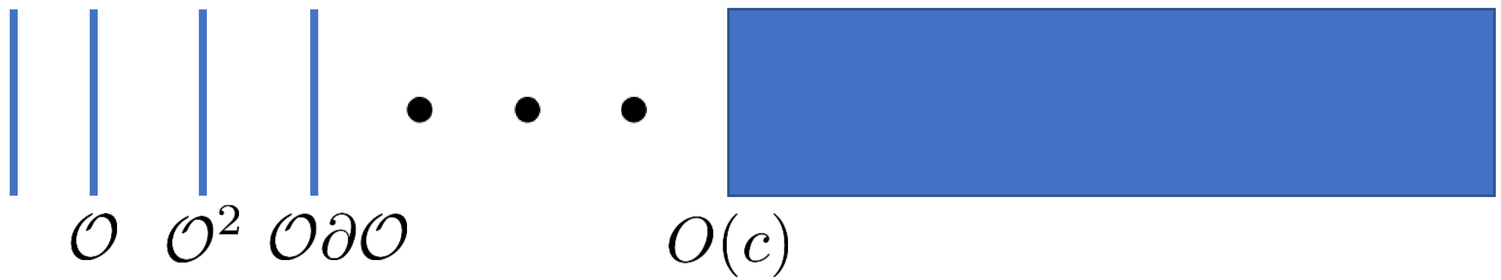

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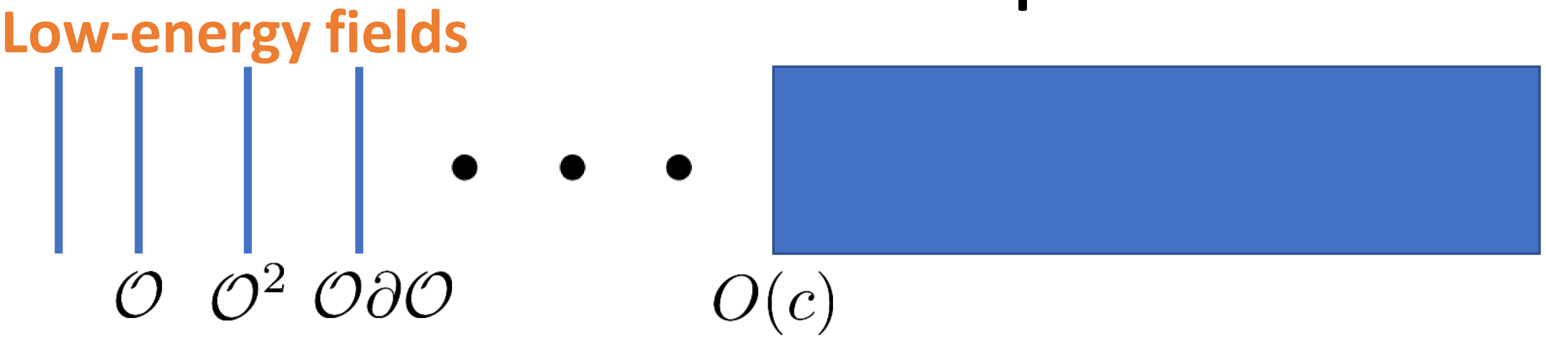

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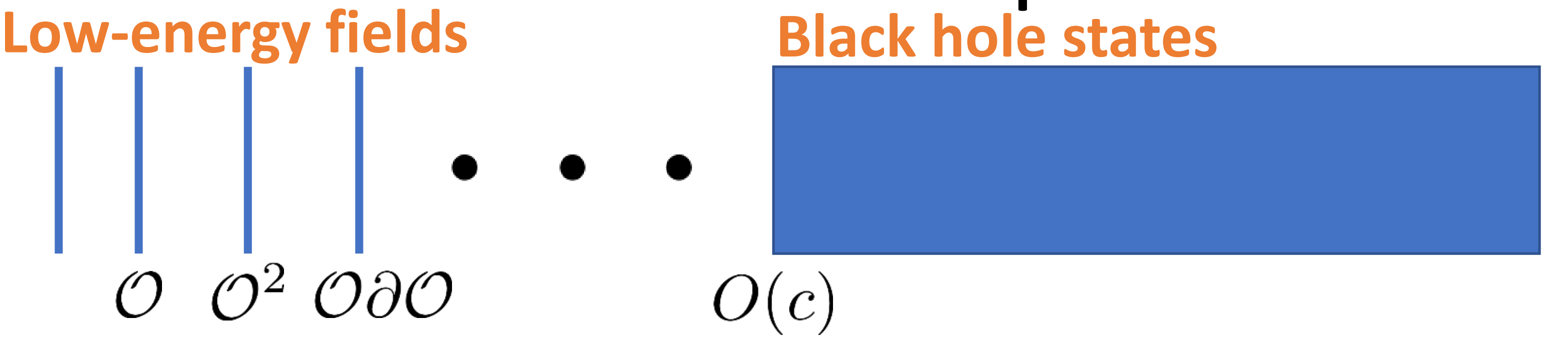

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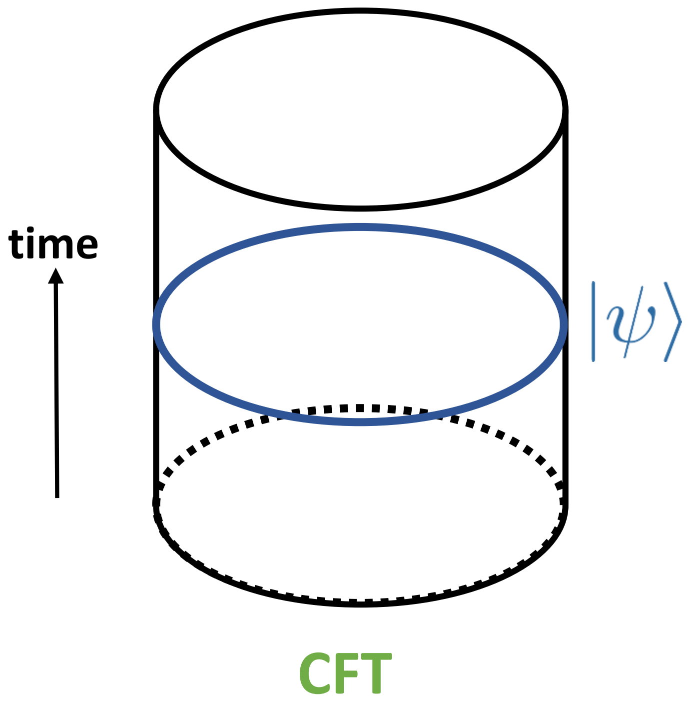

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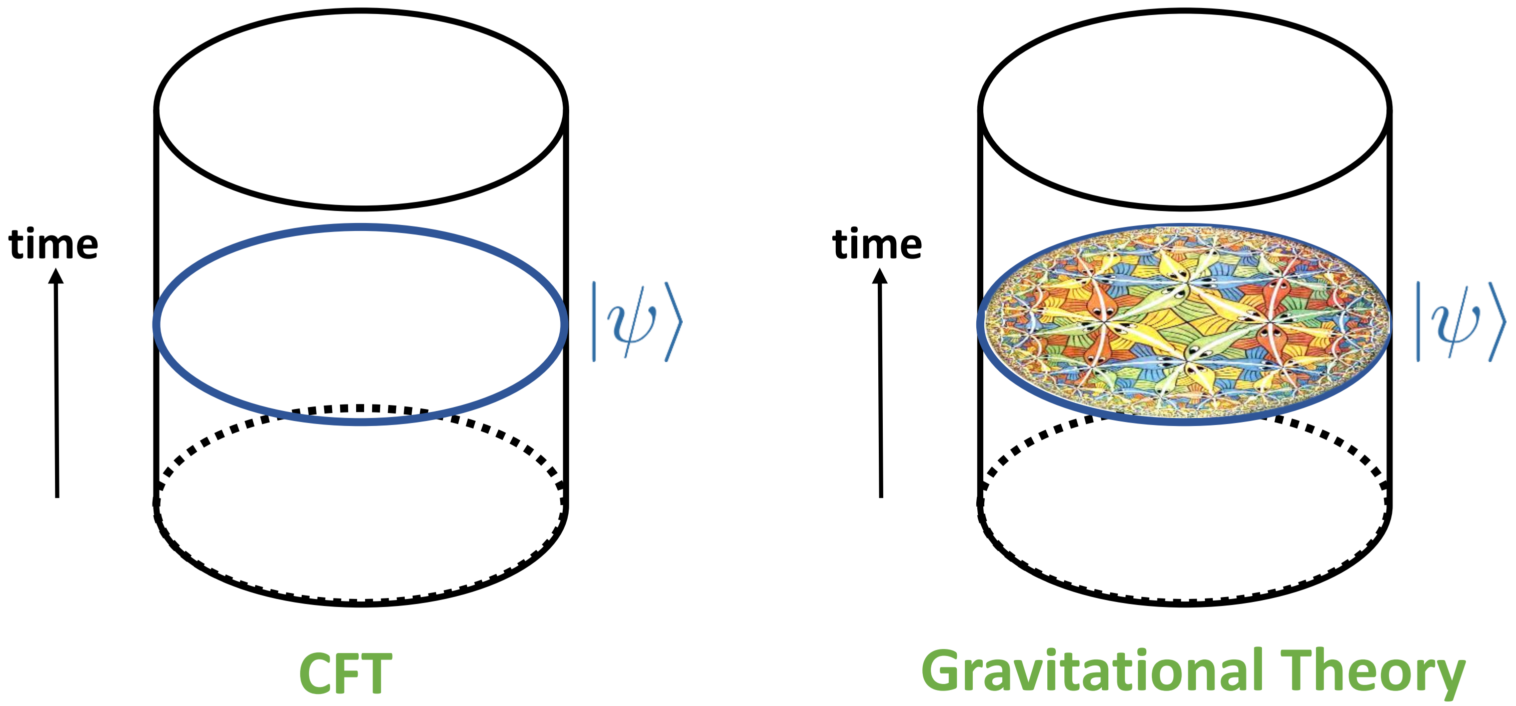

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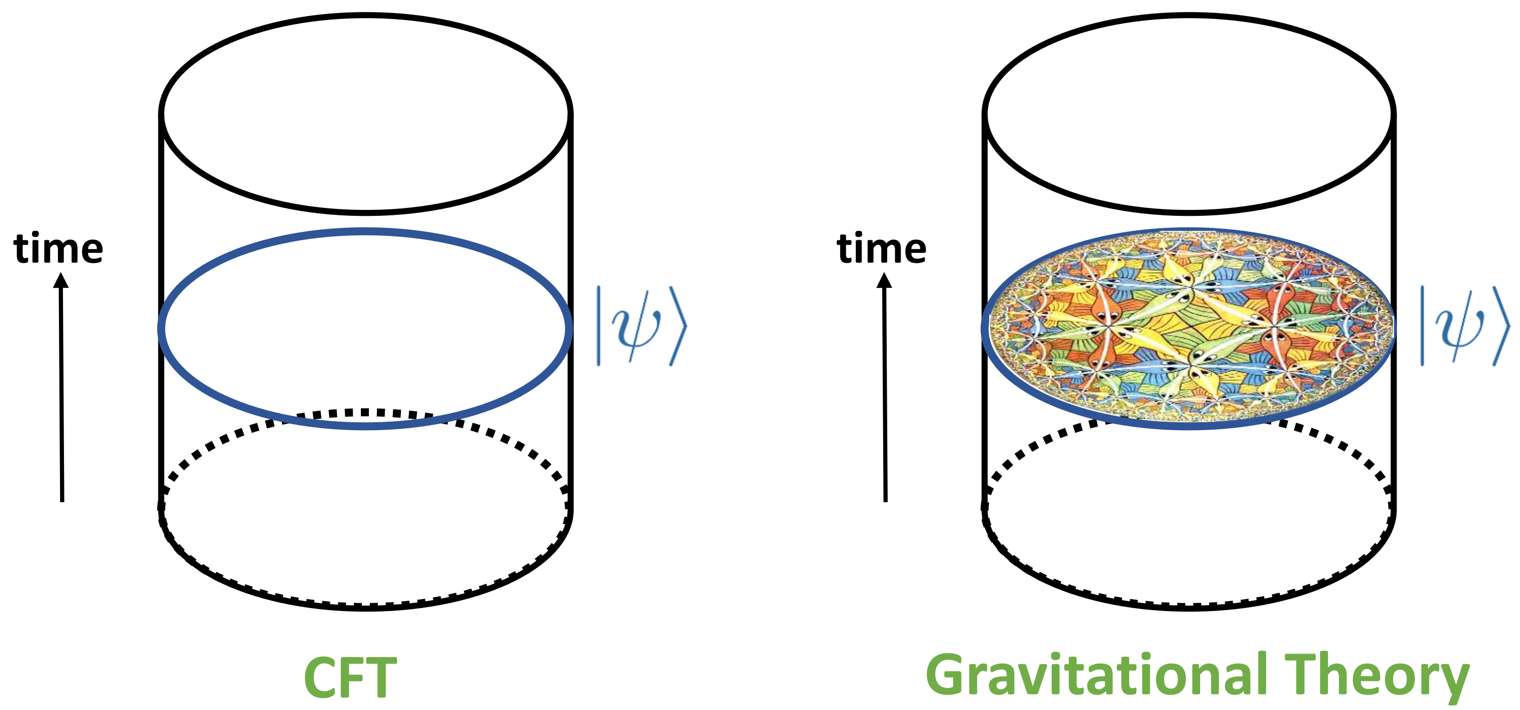

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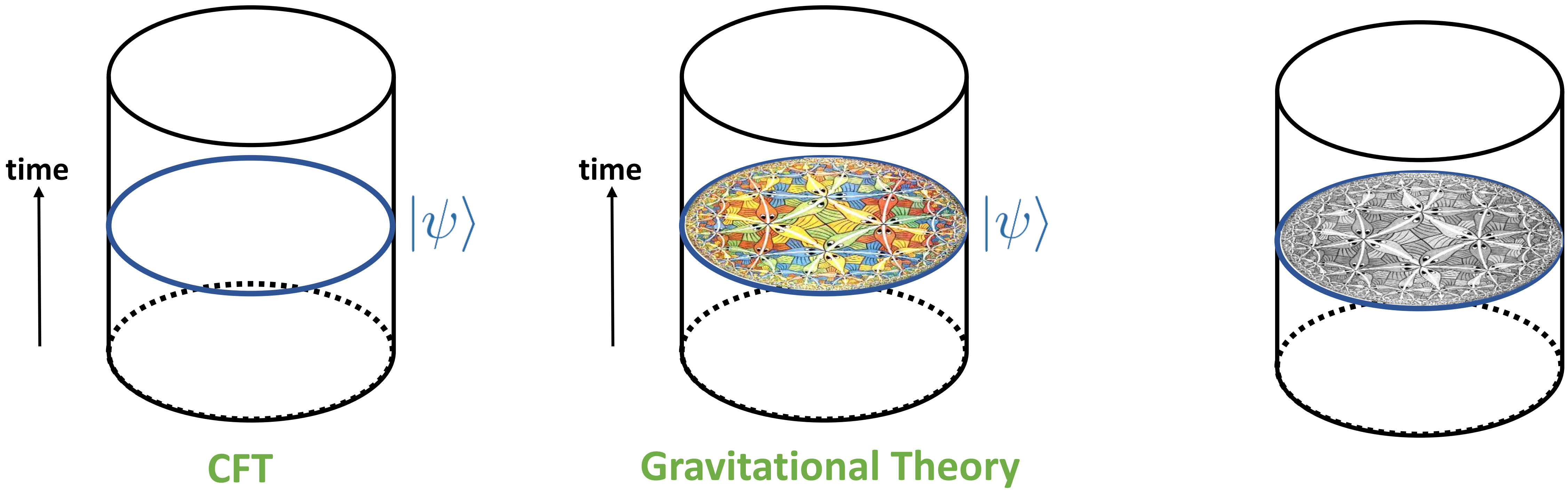

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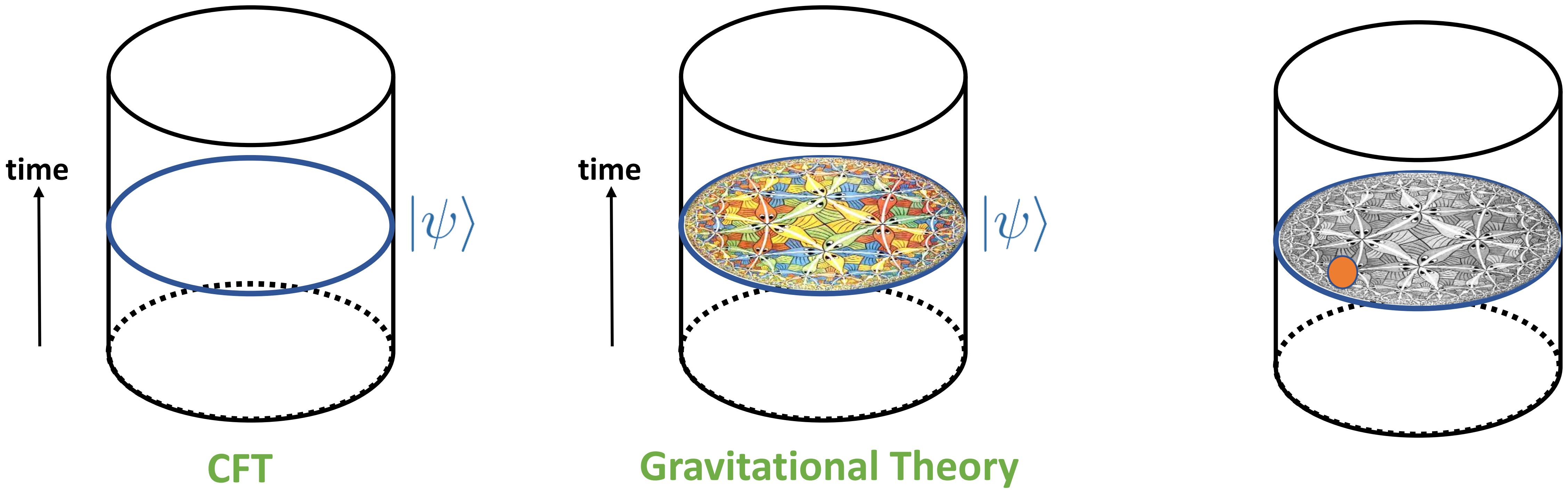

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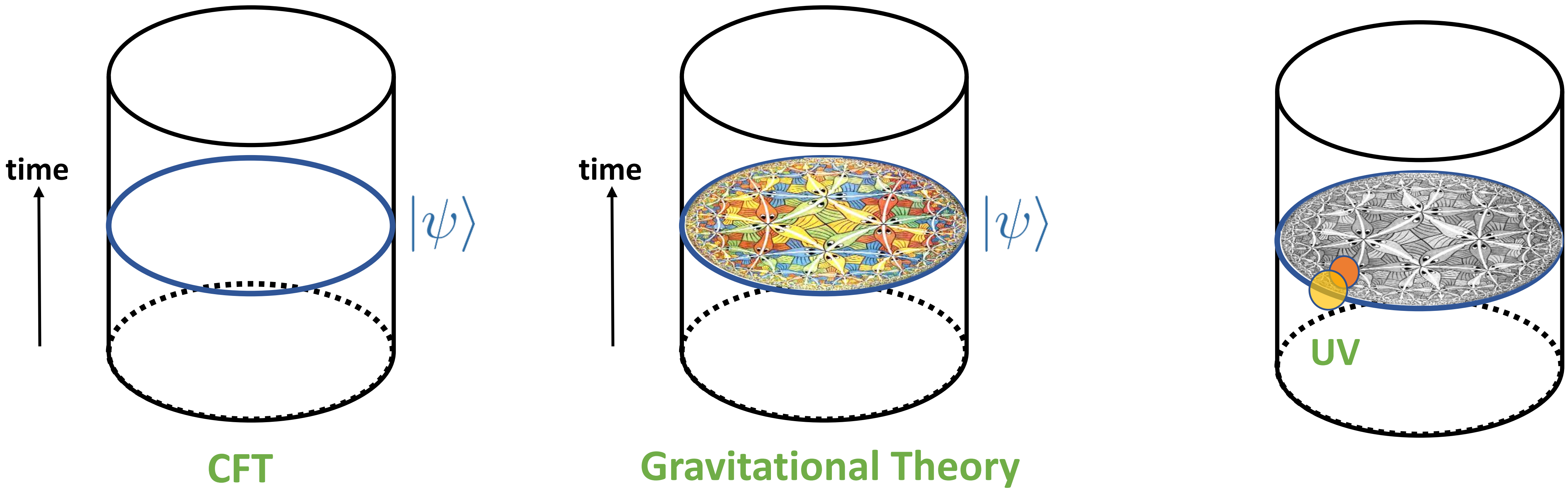

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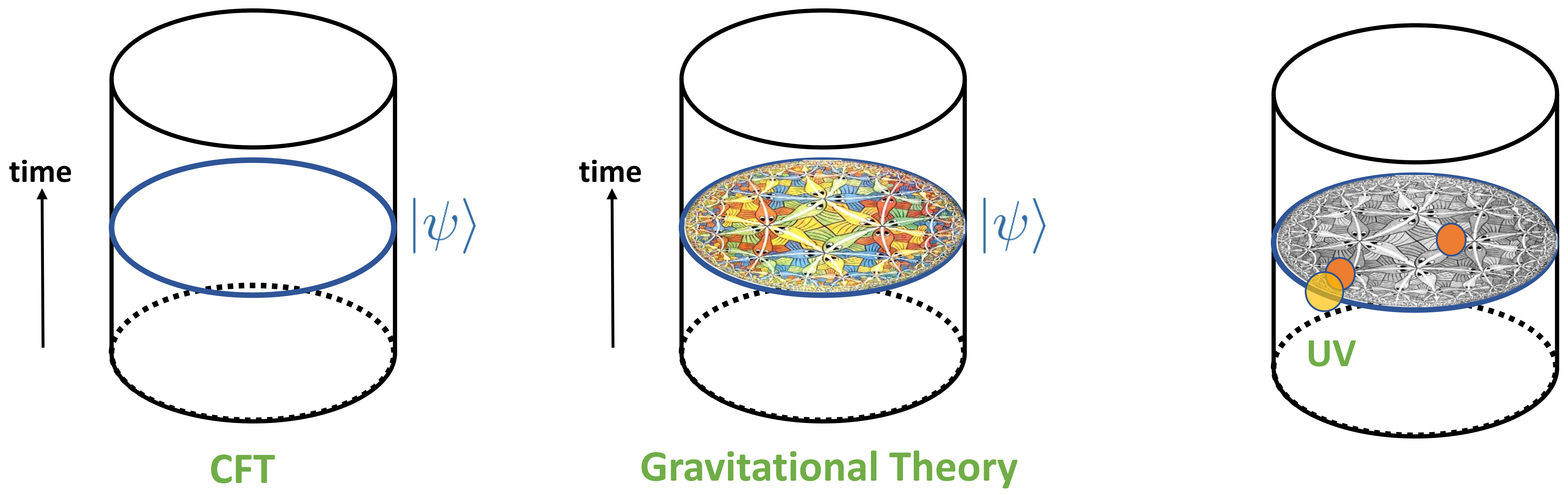

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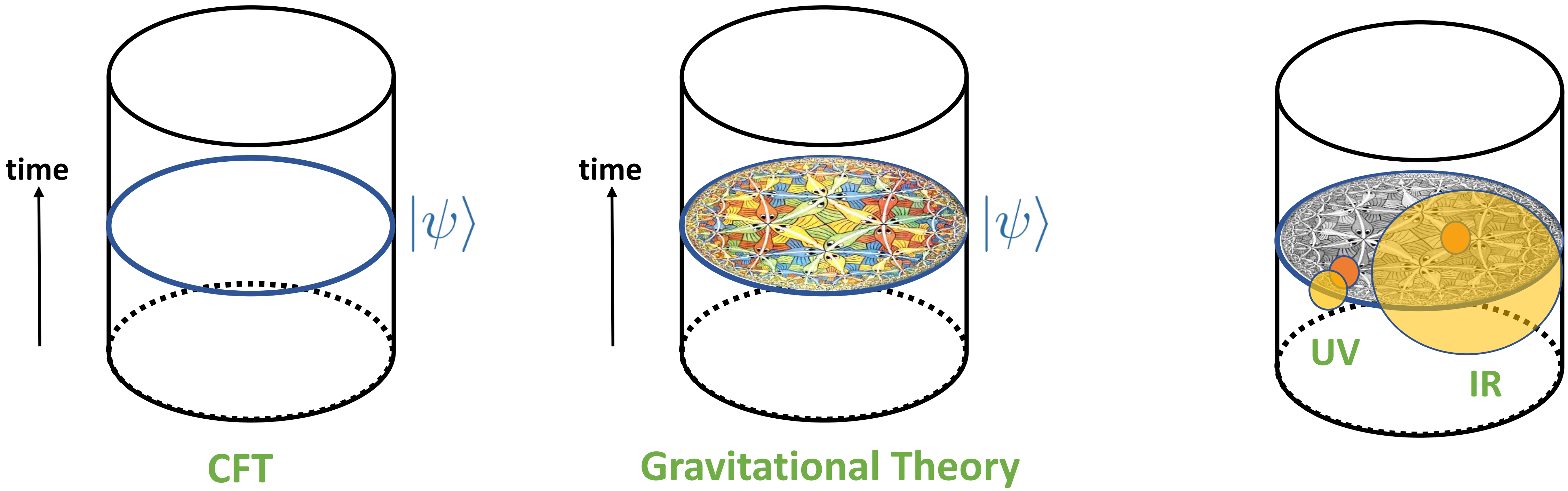

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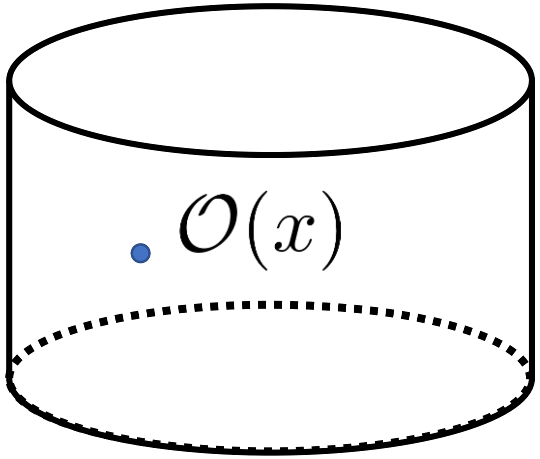

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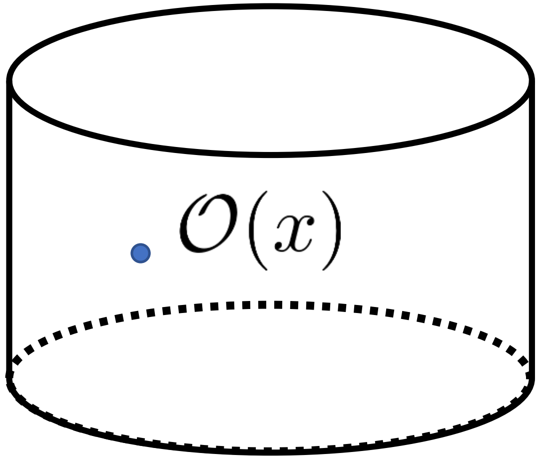

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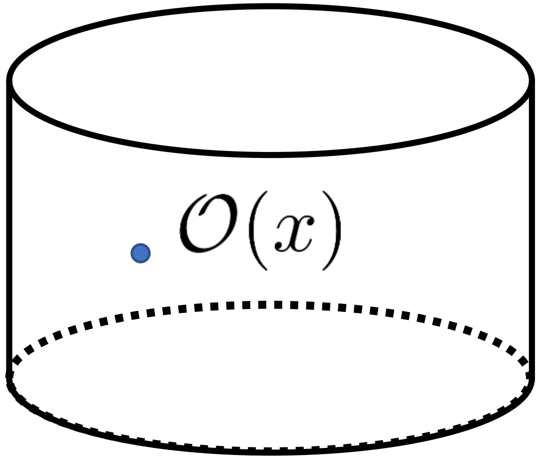

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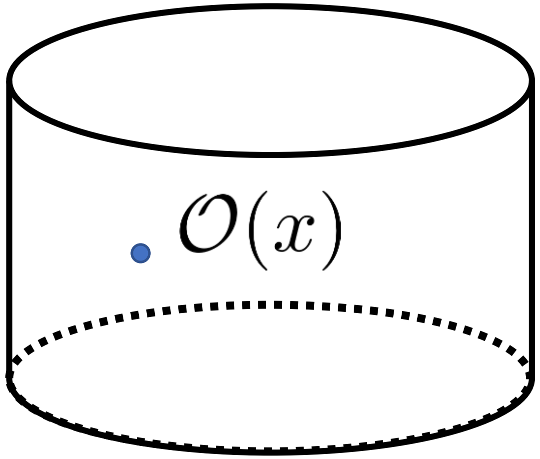

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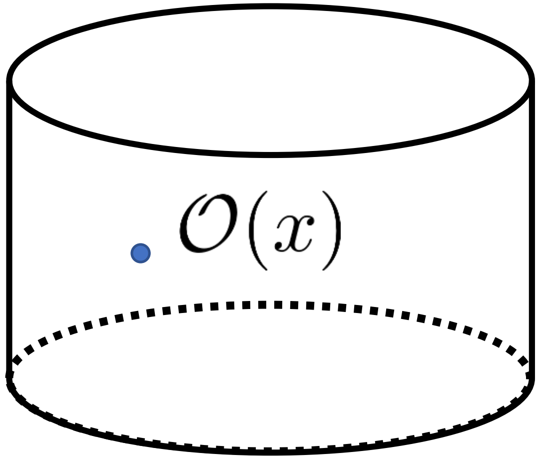

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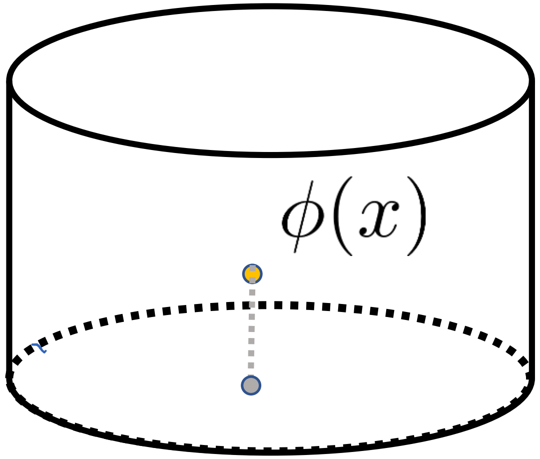

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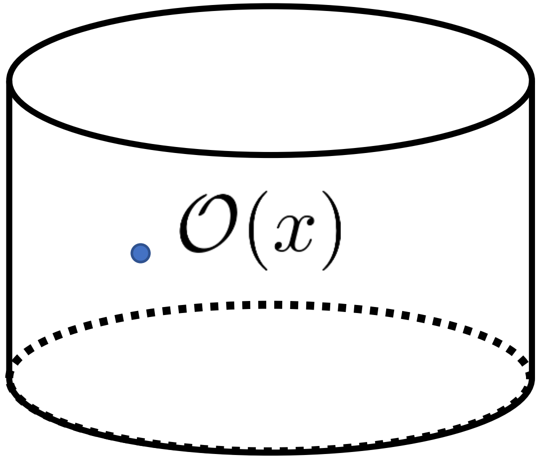

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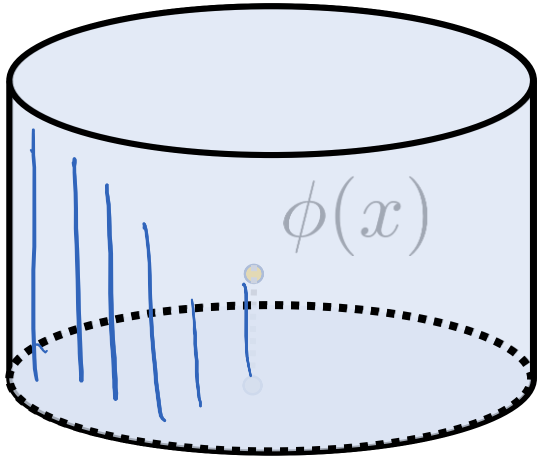

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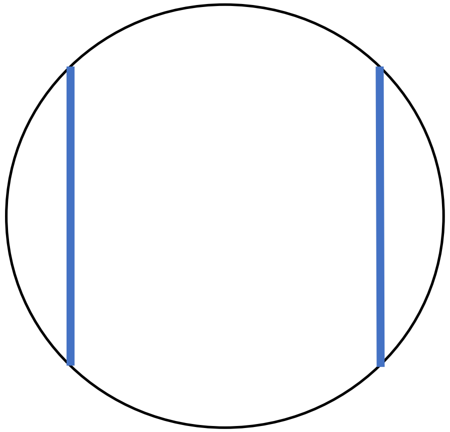

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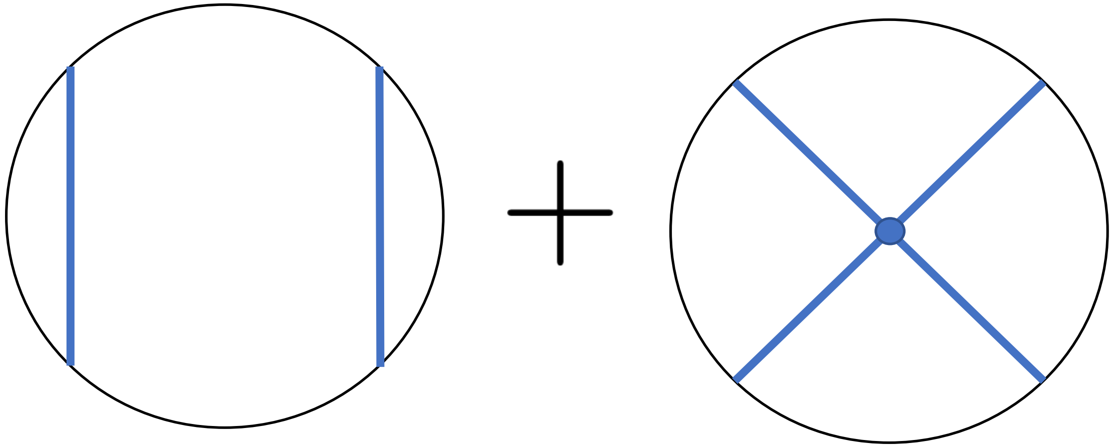

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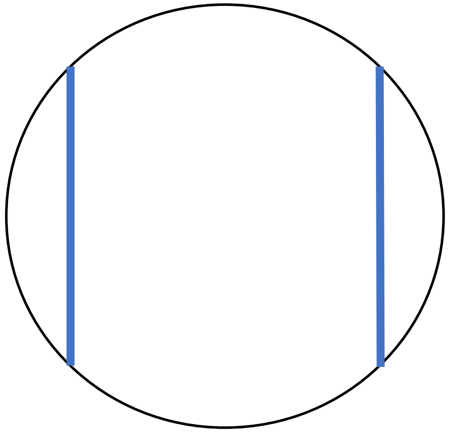
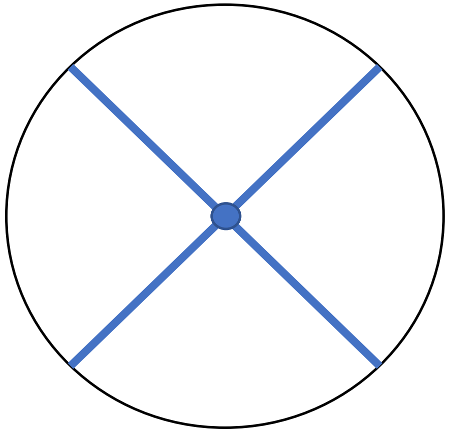
$\langle \mathcal{O}_1 \mathcal{O}_2 \mathcal{O}_3 \mathcal{O}_4 \rangle =$  $+$  $+ \ldots$

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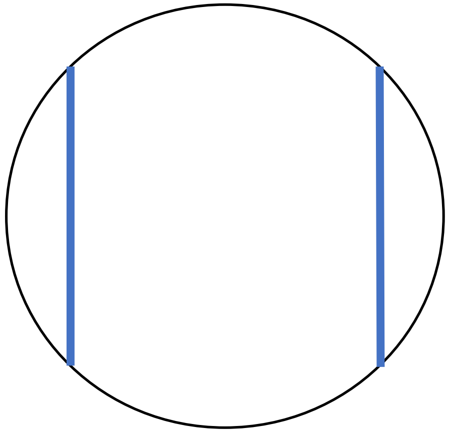
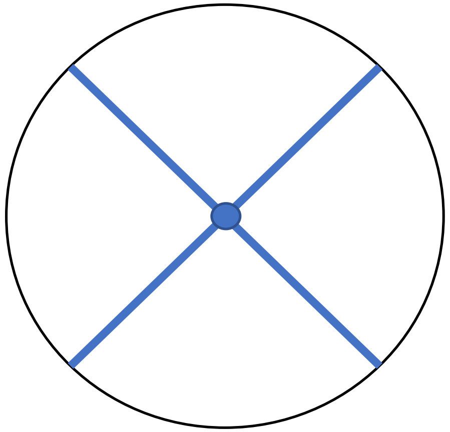
$$\langle \mathcal{O}_1 \mathcal{O}_2 \mathcal{O}_3 \mathcal{O}_4 \rangle =$$  $$+$$  $$+ \ldots$$

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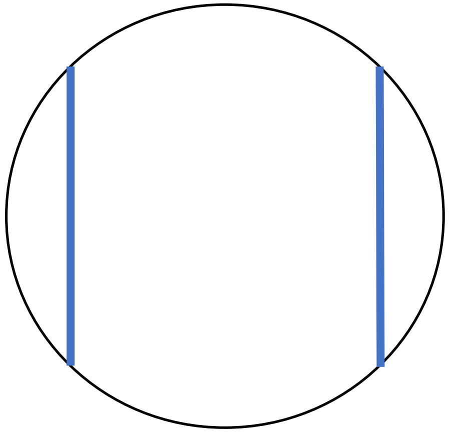
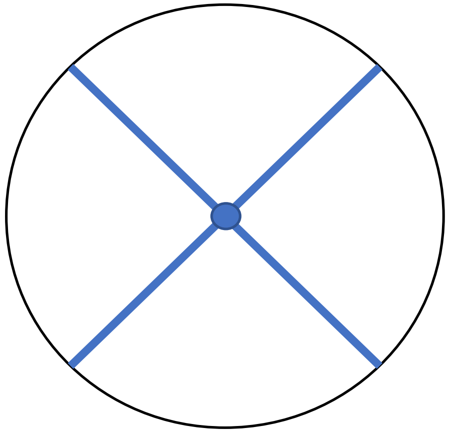
$$\langle \mathcal{O}_1 \mathcal{O}_2 \mathcal{O}_3 \mathcal{O}_4 \rangle =$$  $+$  $+ \ldots$

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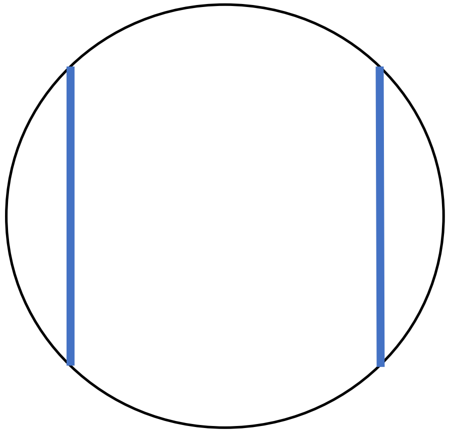
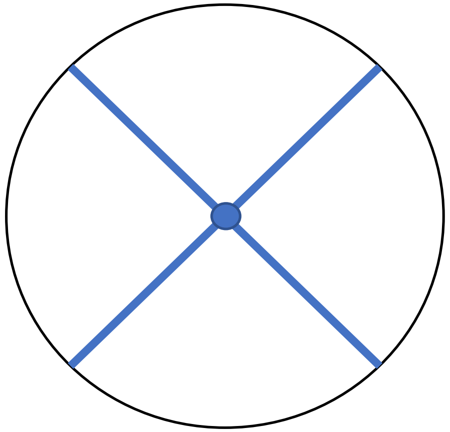
$$\langle \mathcal{O}_1\mathcal{O}_2\mathcal{O}_3\mathcal{O}_4 \rangle =$$  $$+$$  $$+ \ldots$$

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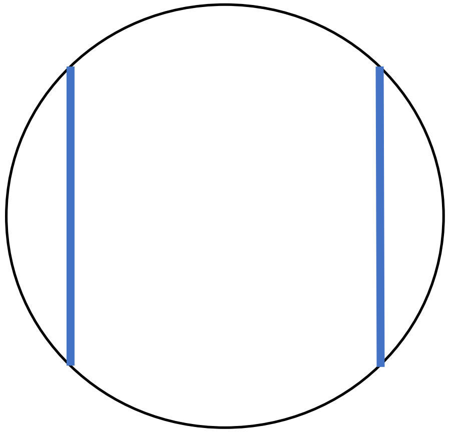

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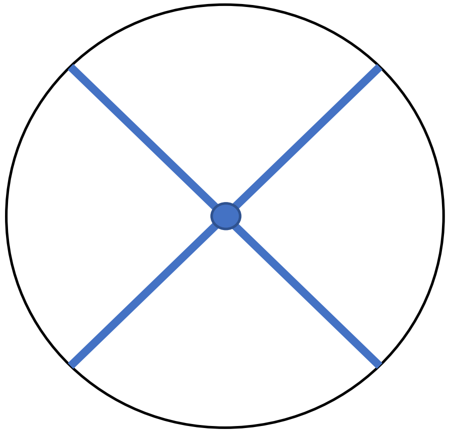

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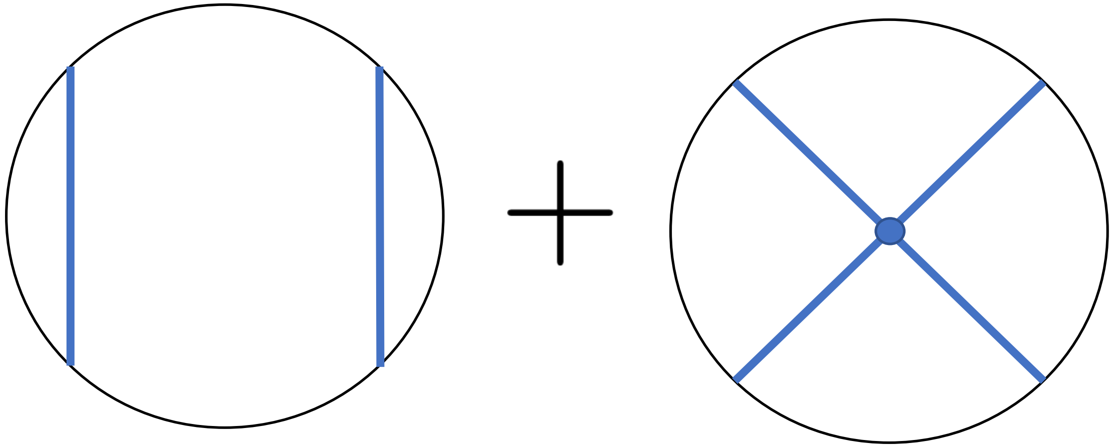

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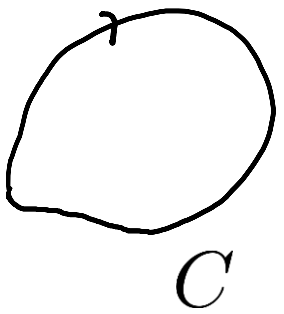

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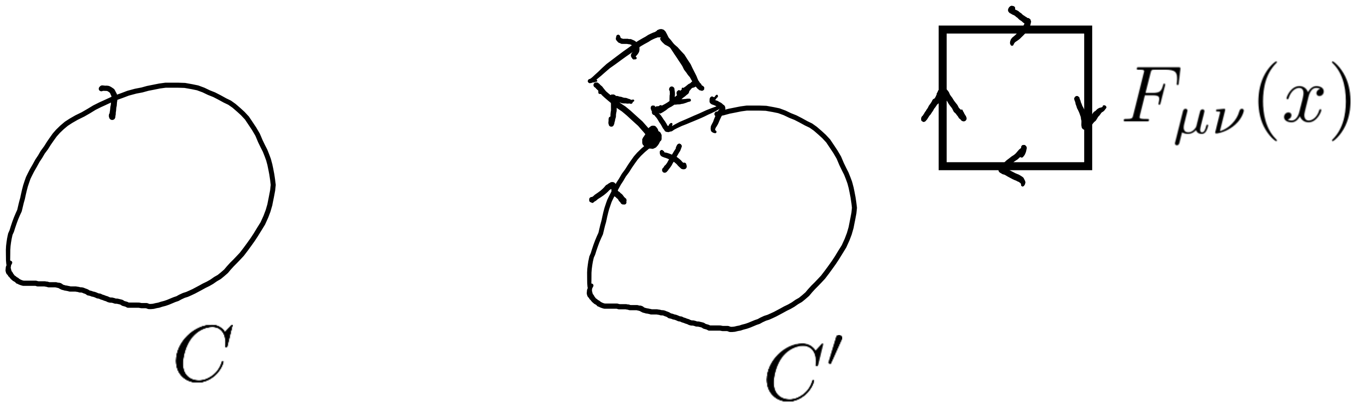

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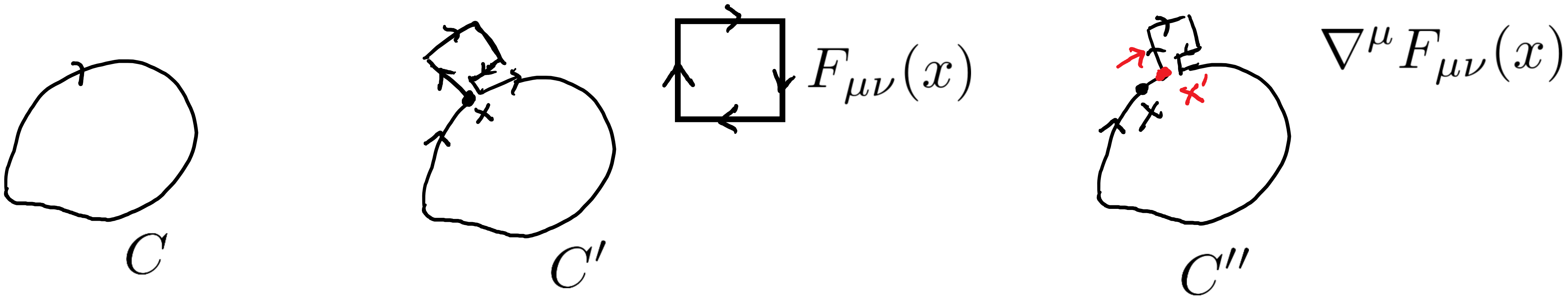

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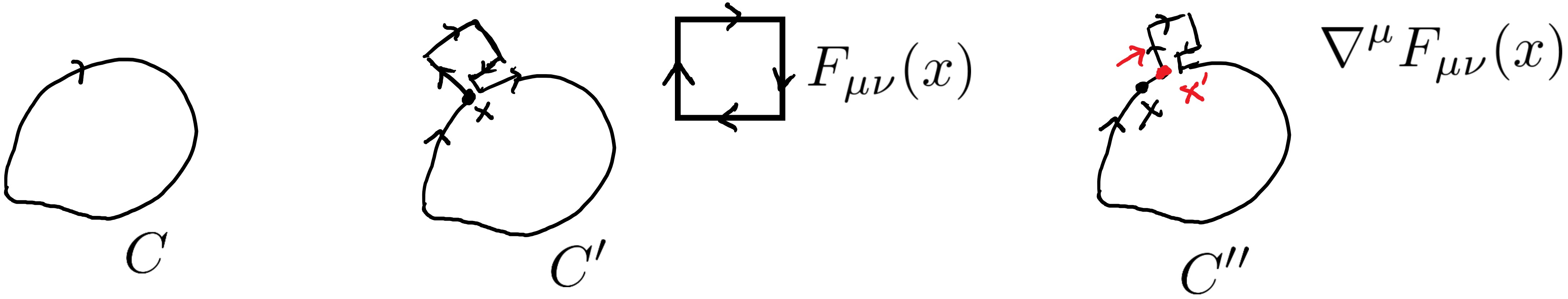

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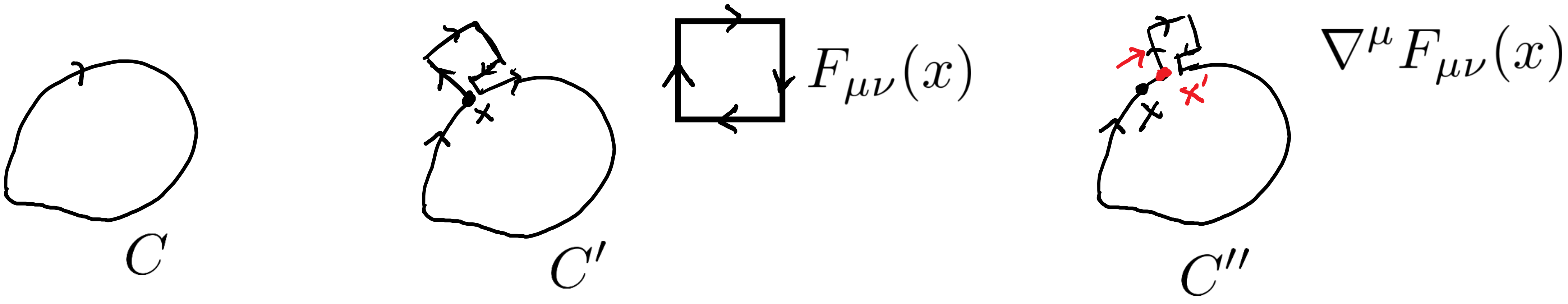

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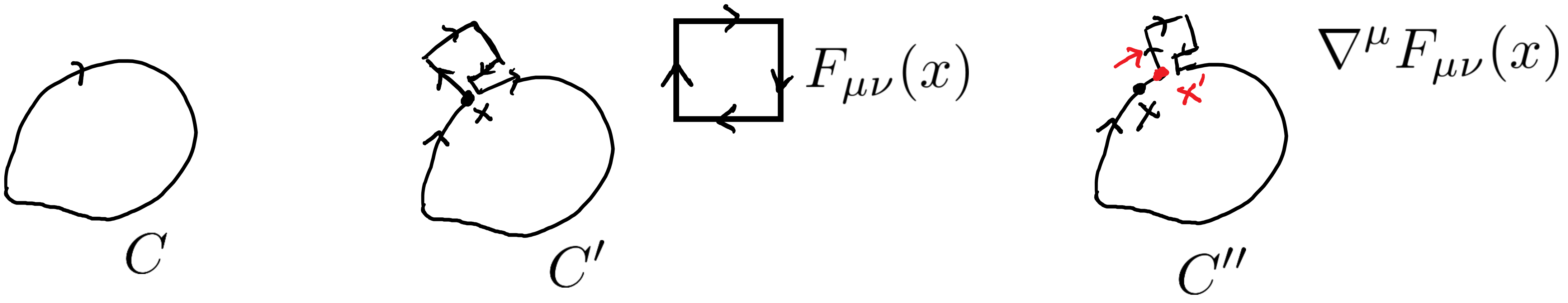

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Intertwining Operators

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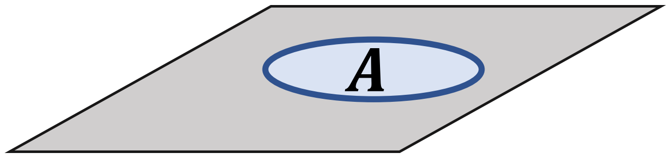

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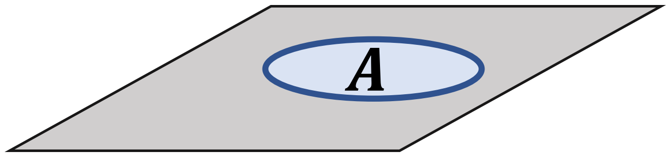

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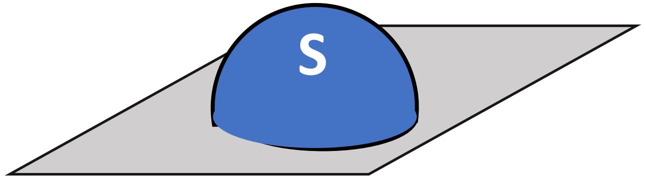

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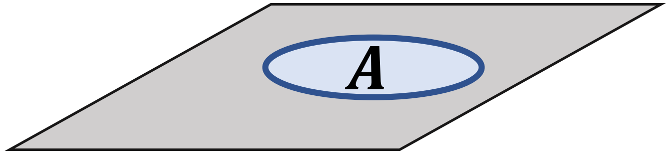

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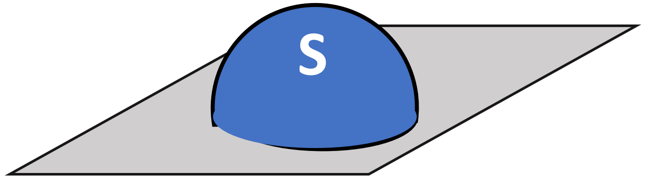

The **area of a minimal surface** S in the gravitational dual

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Loop Space = ?

We need to understand: **what is the most natural loop/phase space for gravitational physics in AdS/CFT?**

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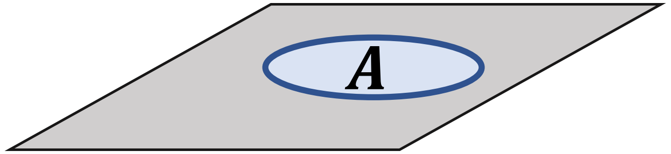

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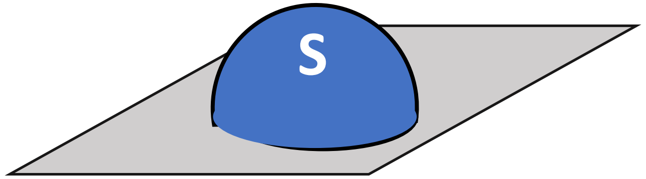

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Might think of spacetime as geometrization of this entanglement data!

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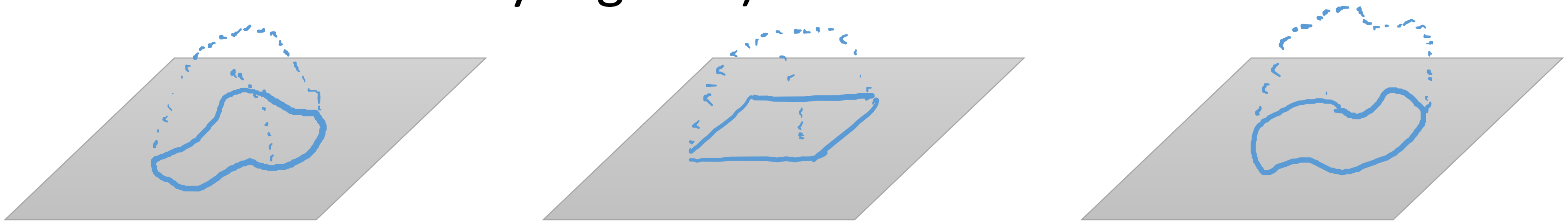

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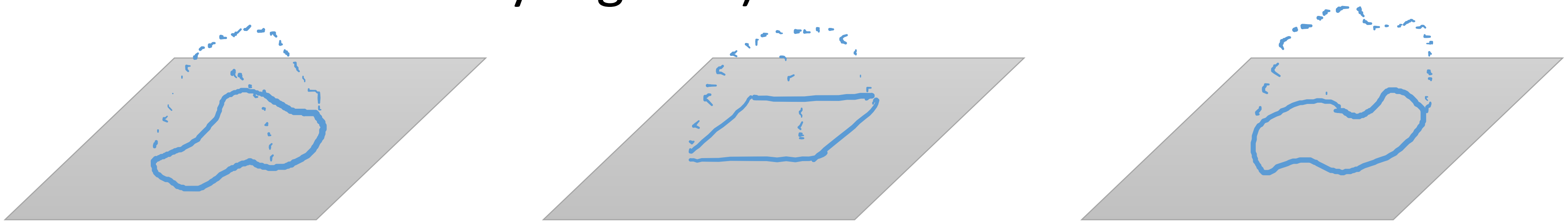

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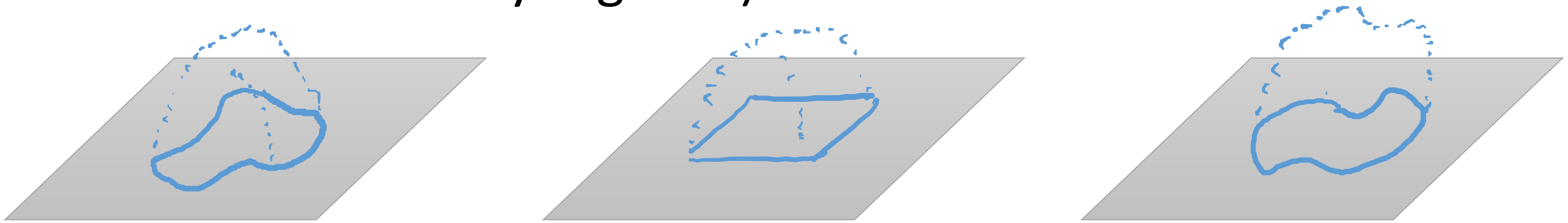

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- **Define our loop space to be the space of minimal surfaces with spherical boundary conditions** (in any frame).
  - We will give it a new name: **Kinematic Space.**

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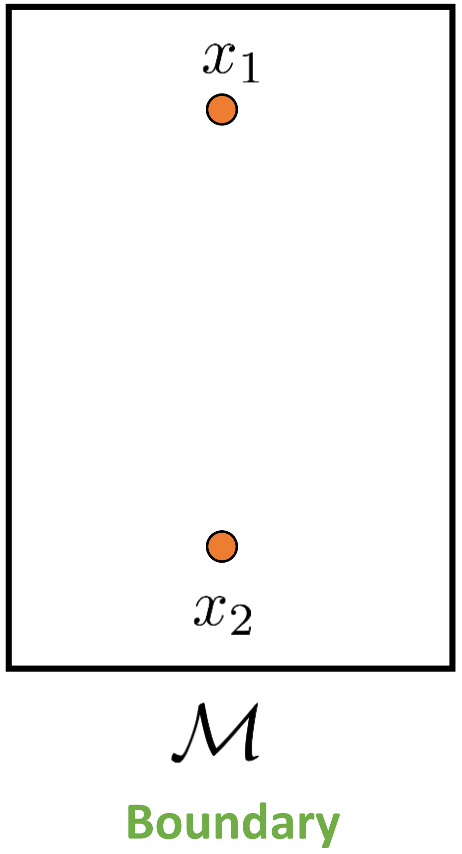

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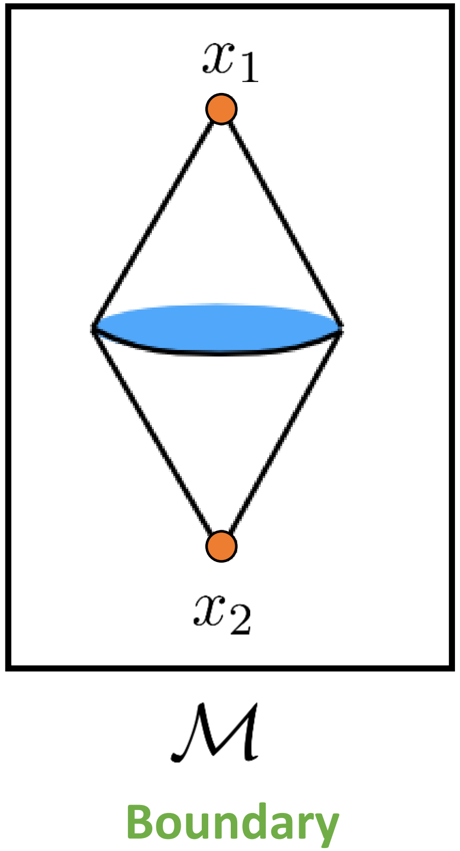

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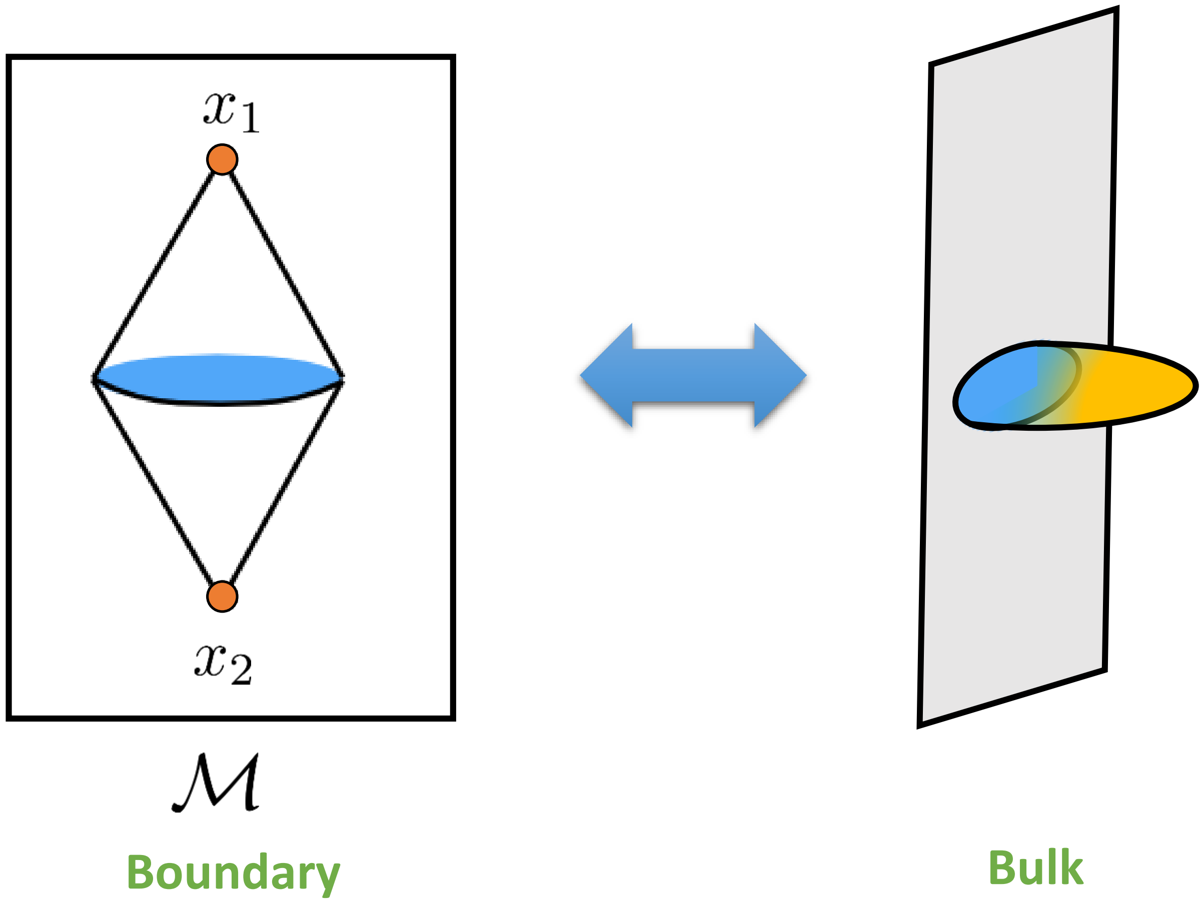

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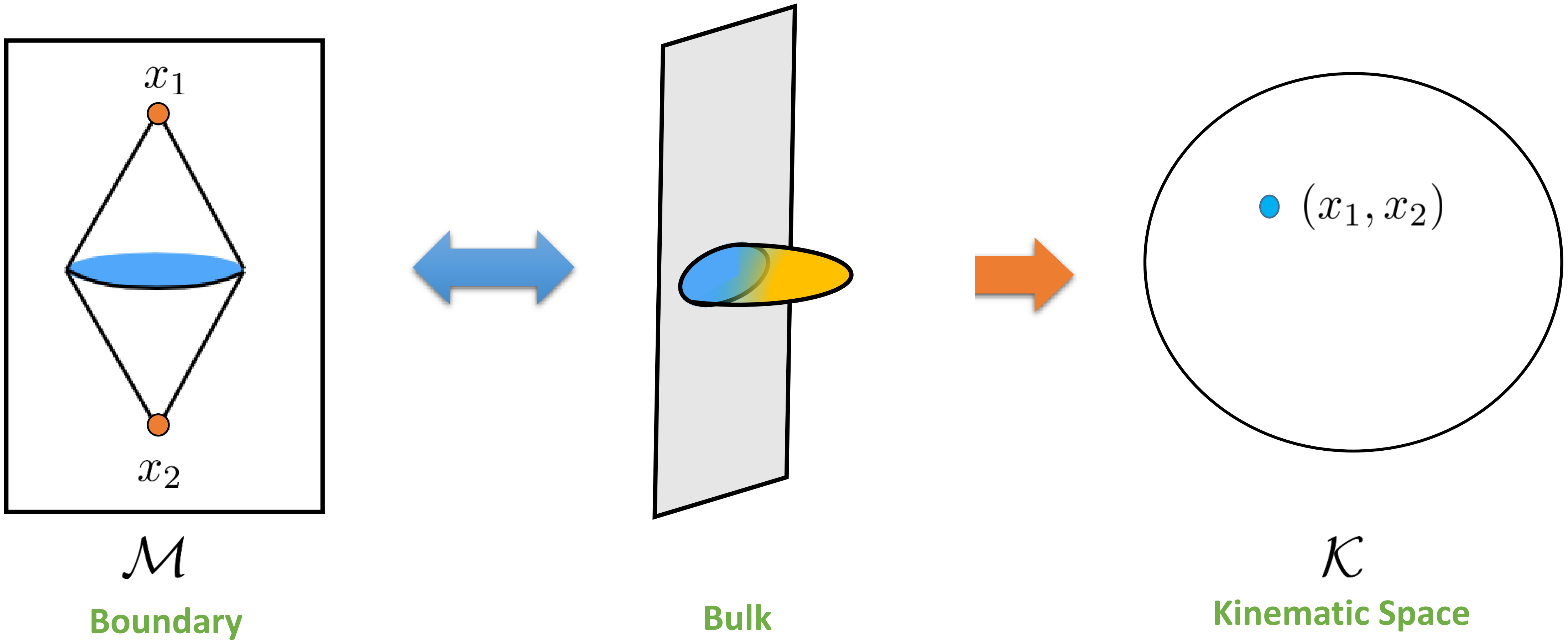

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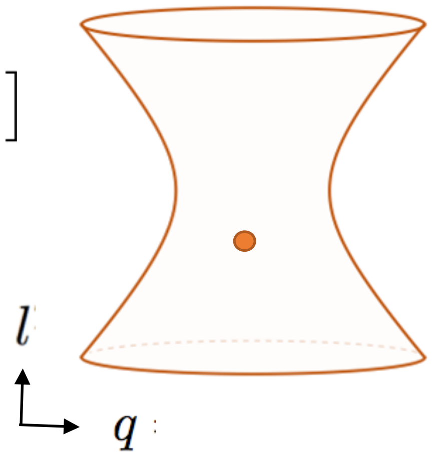

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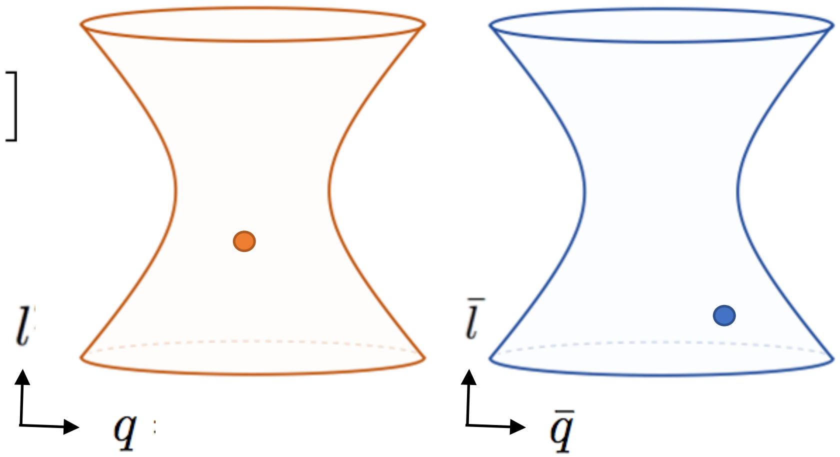

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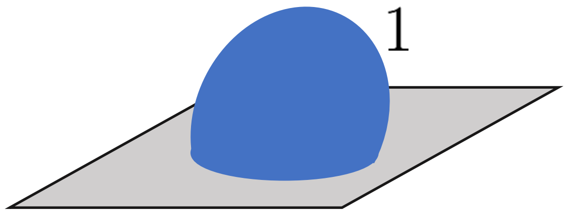

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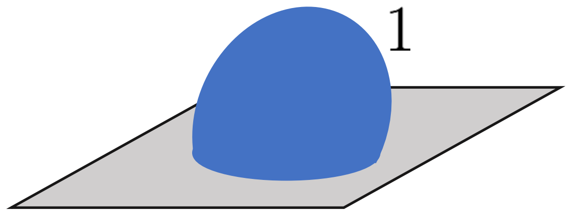

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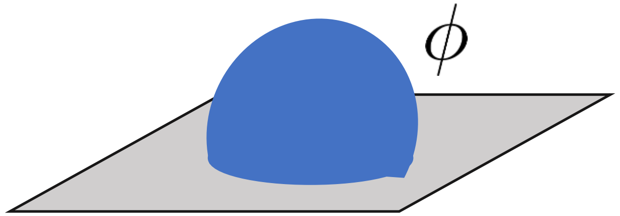

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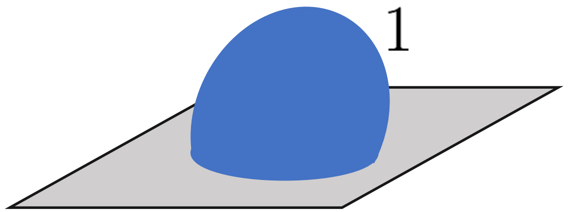

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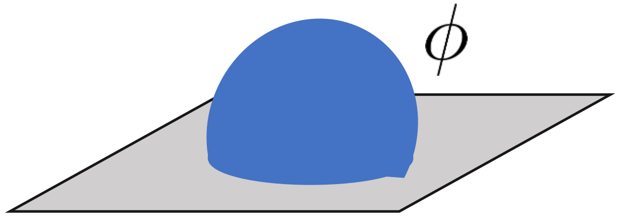

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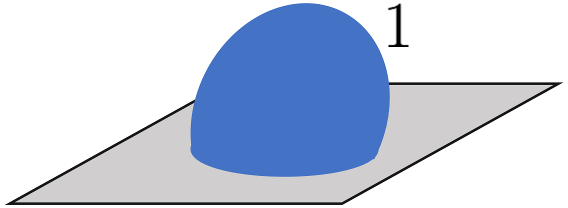

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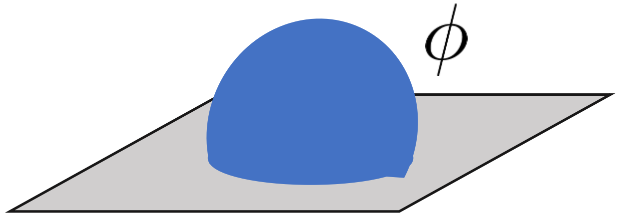

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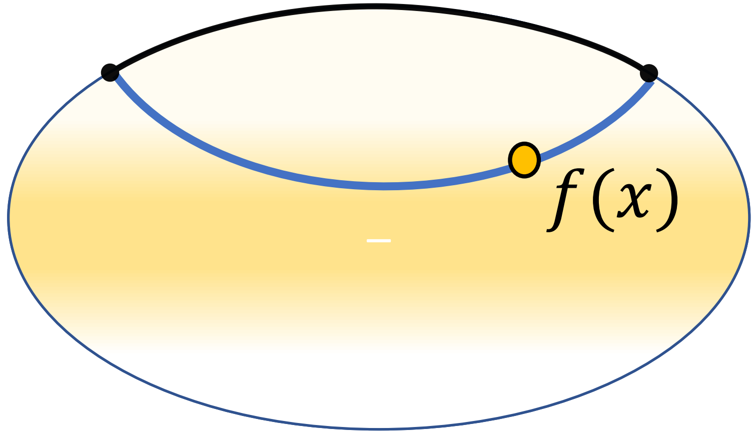

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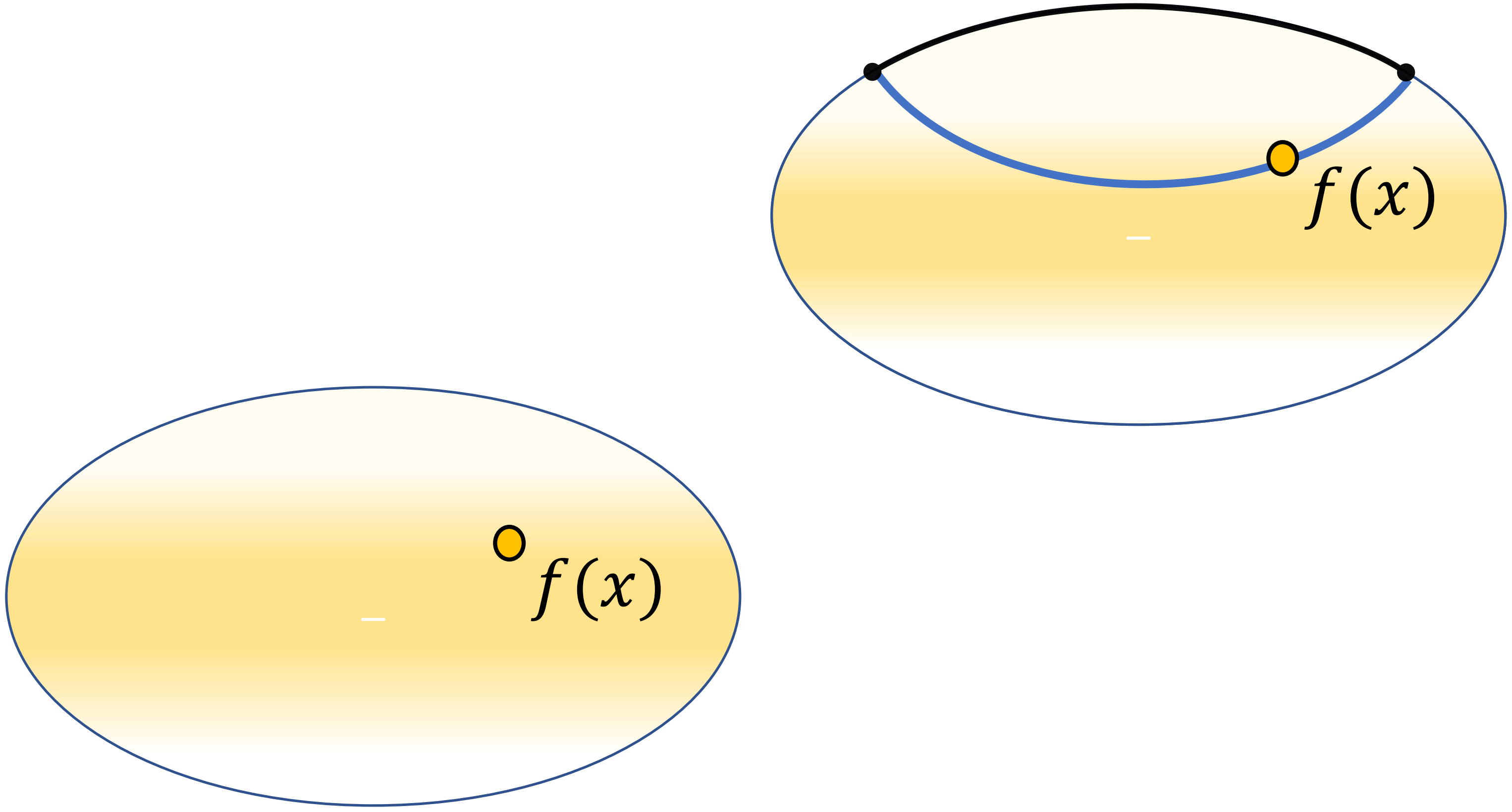

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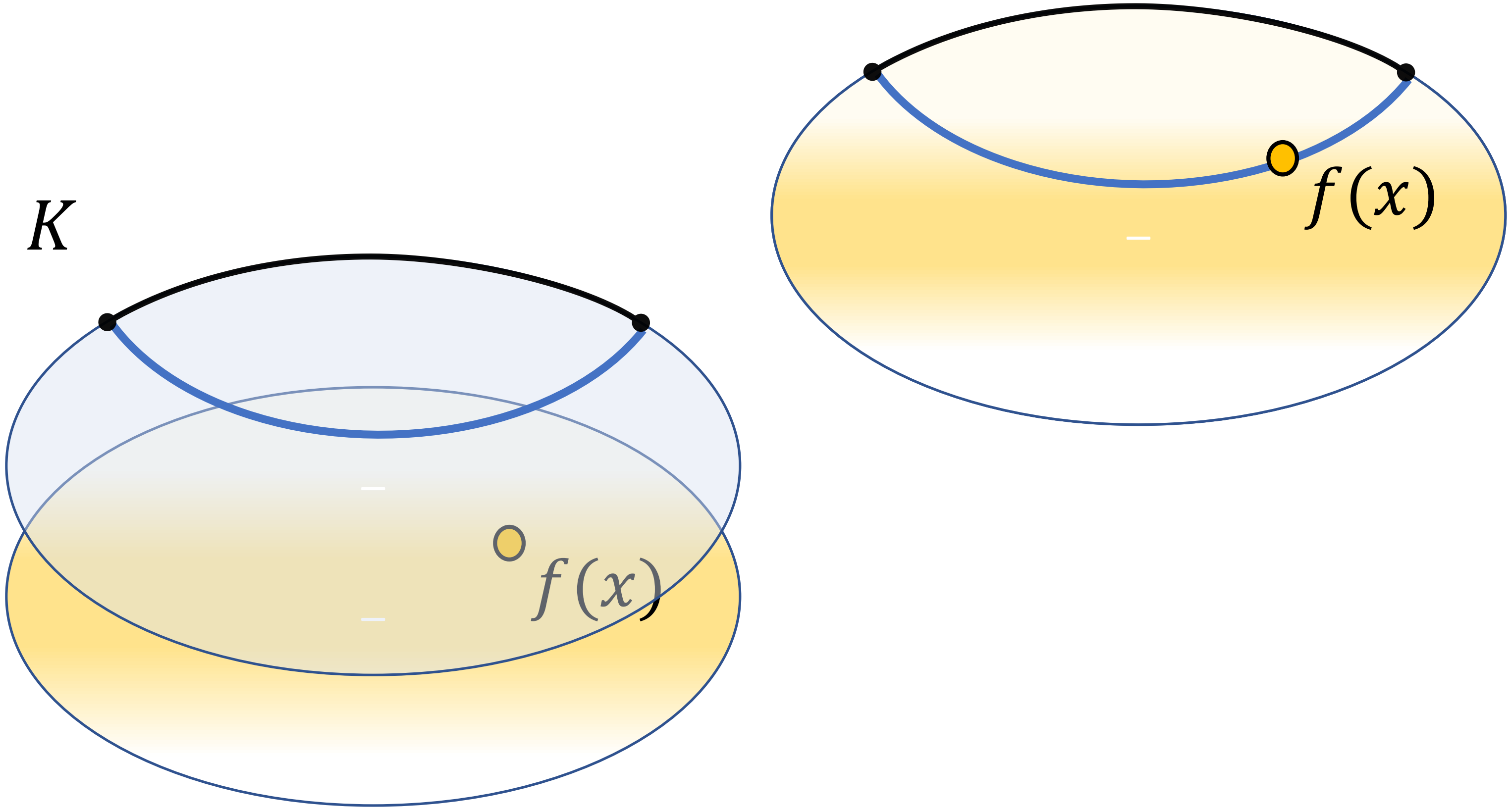

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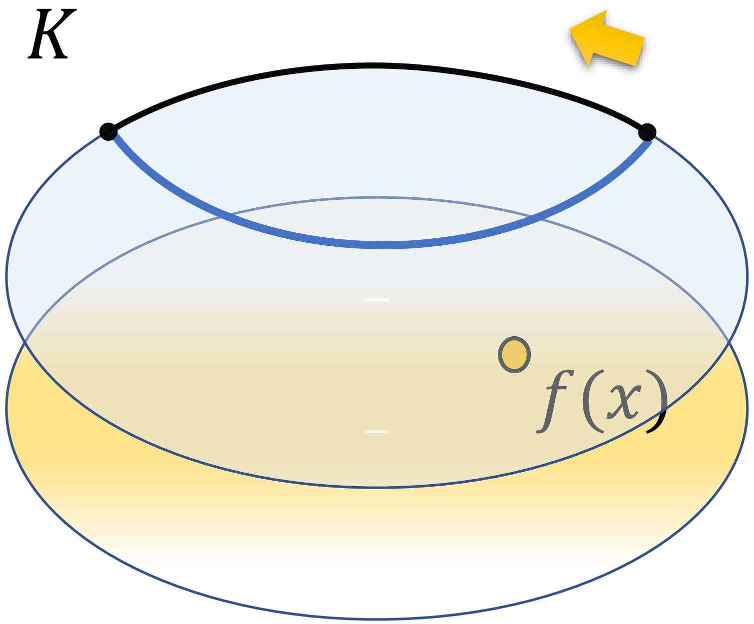

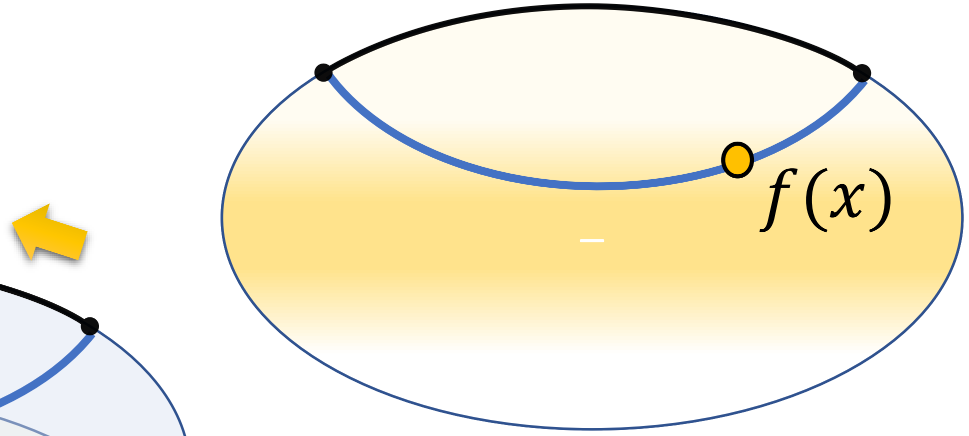

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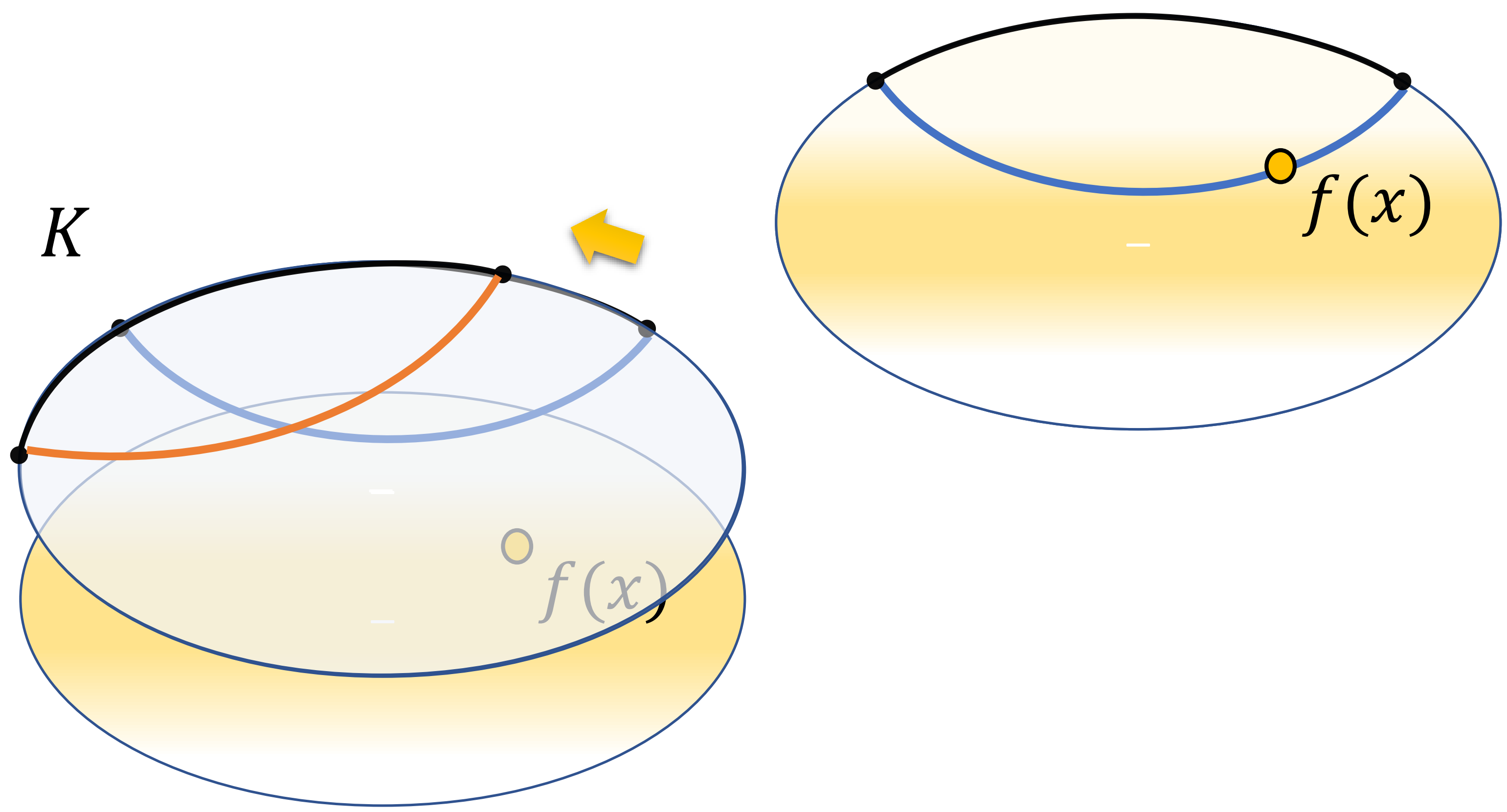

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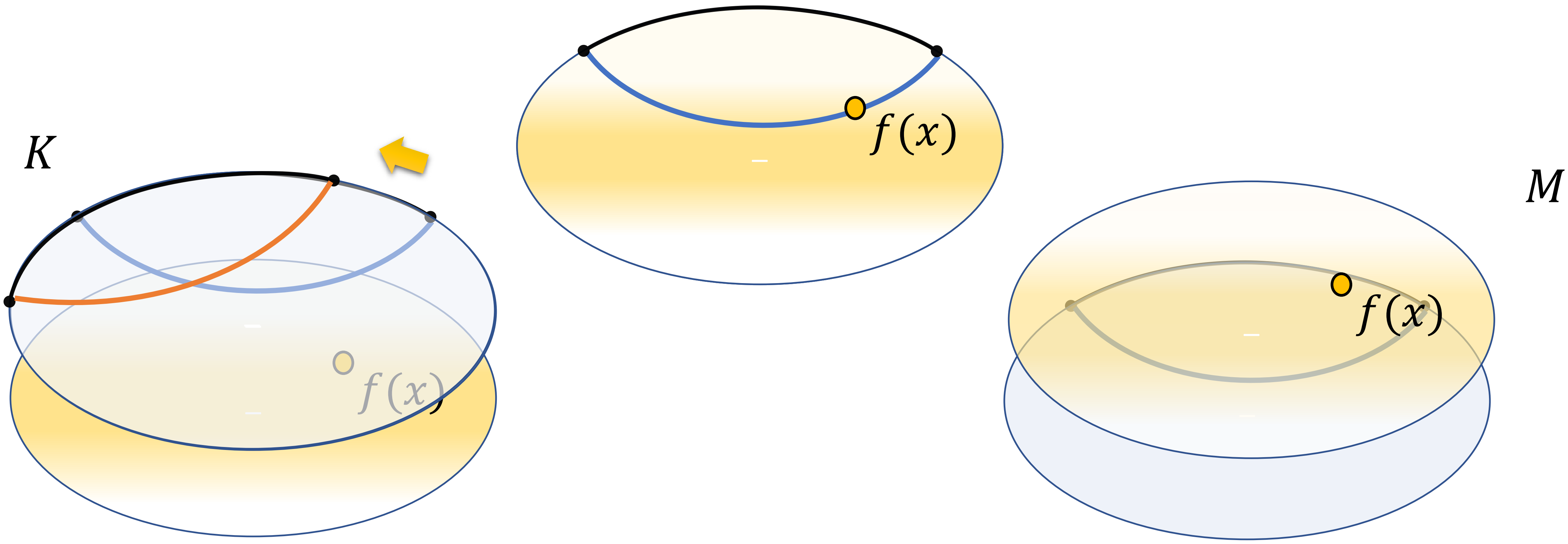

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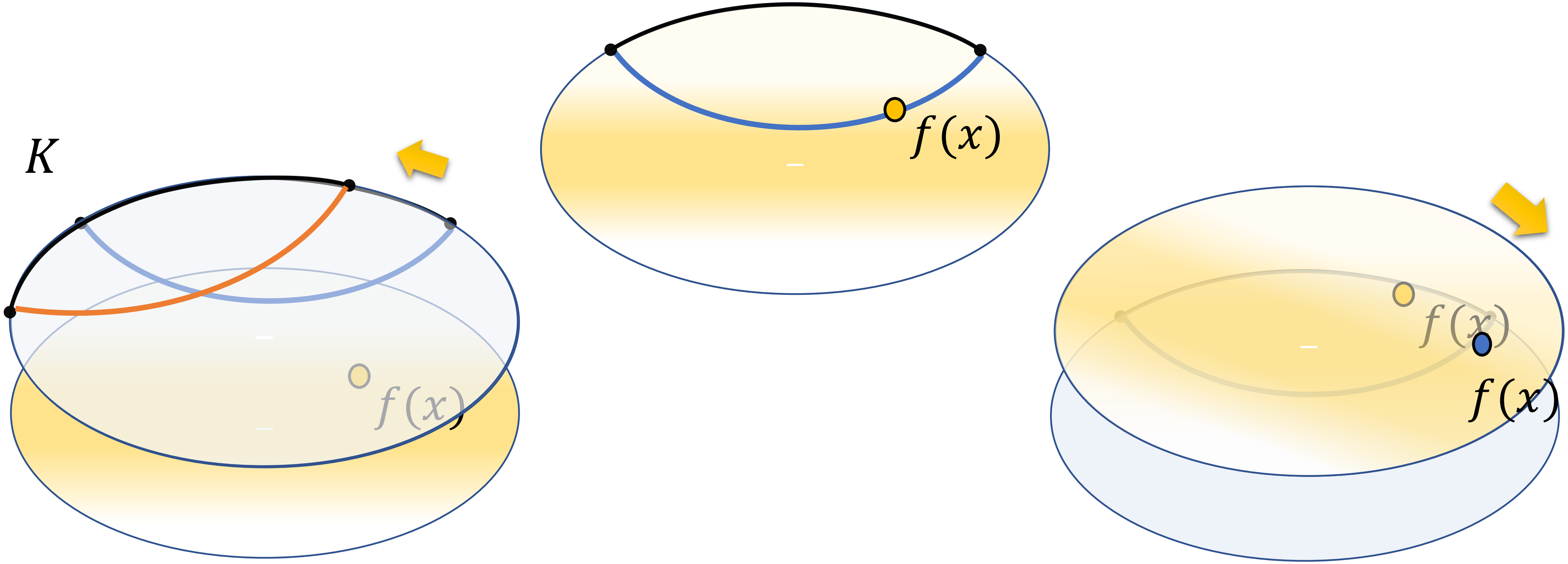

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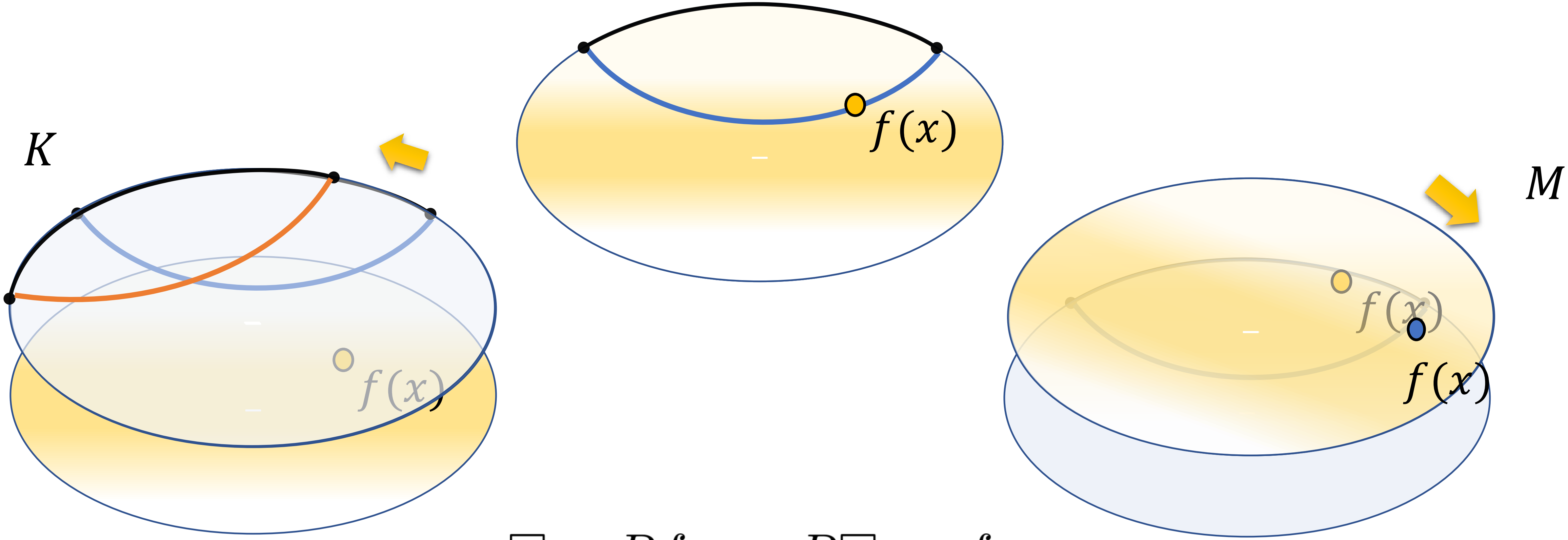

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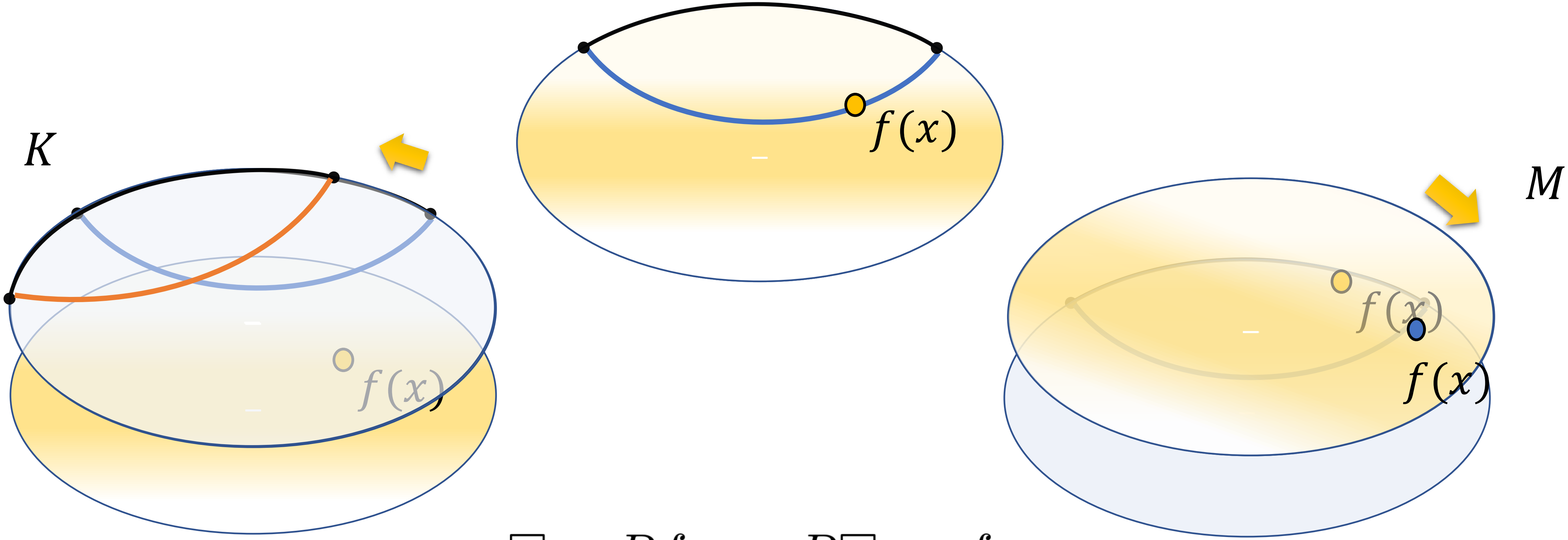

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Loop EOM for free scalar
= Kinematic Free scalar EOM

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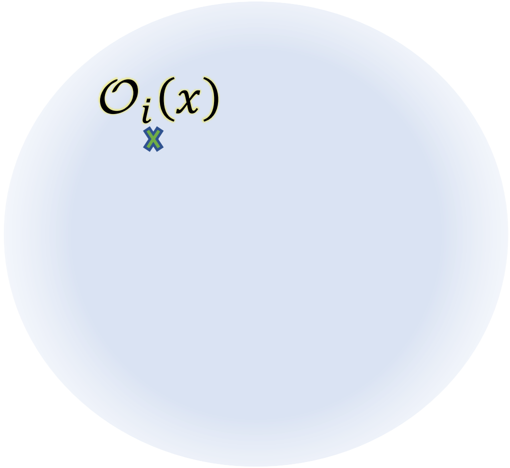

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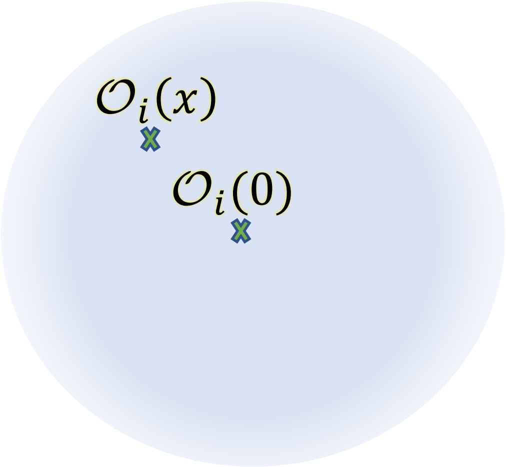

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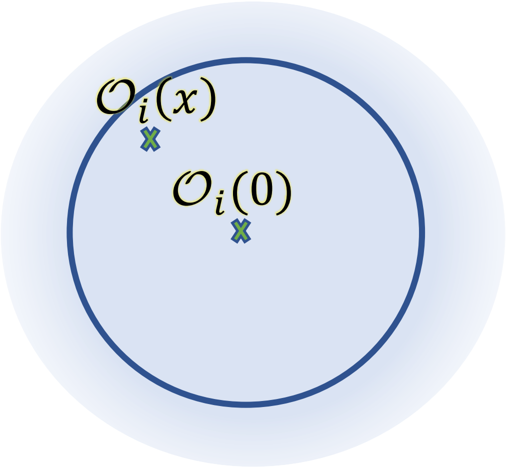

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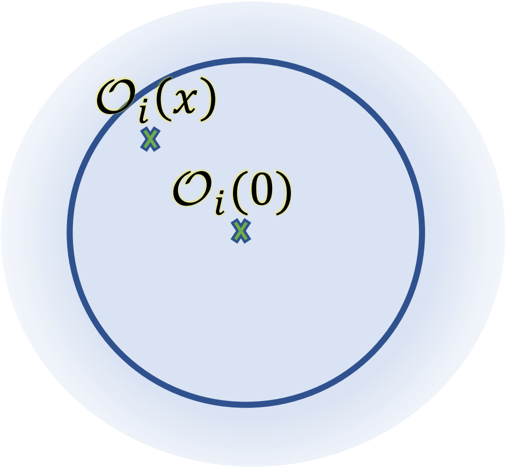

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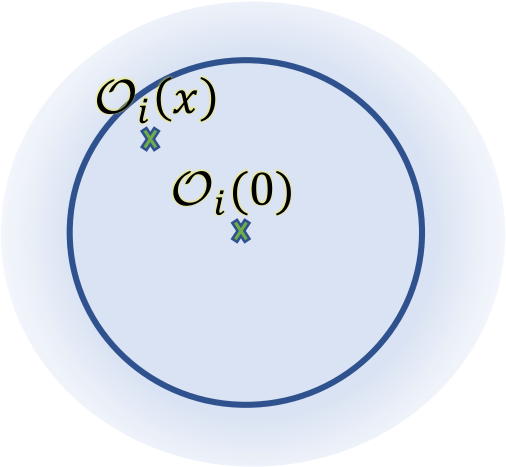

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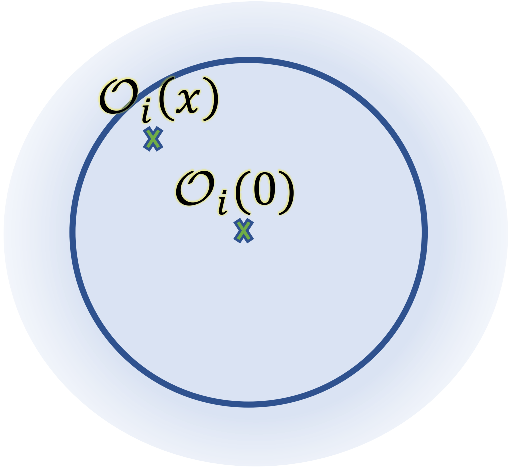

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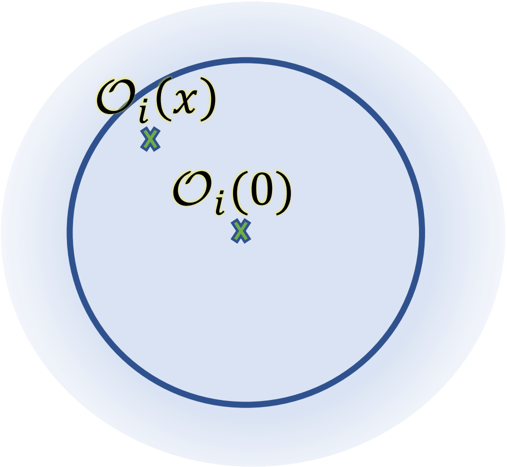

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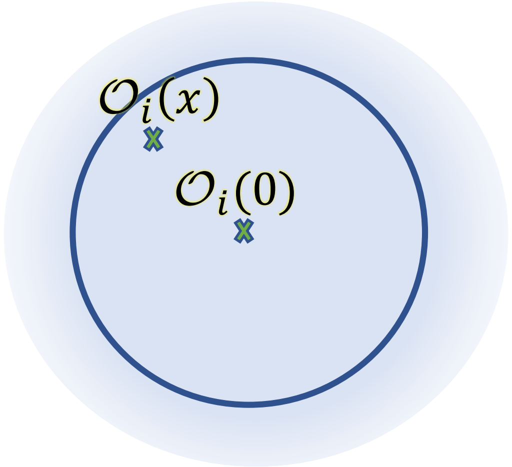

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- We will call $\mathcal{B}_k(x,y)$ the '**OPE Block**'

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The Kinematic Dictionary:

$$\boxed{\mathcal{B}_k\,(x,y) = \tilde{\phi}(\gamma)}$$

[cf. de Boer, Haehl, Heller, Myers; da Cunha, Guica]

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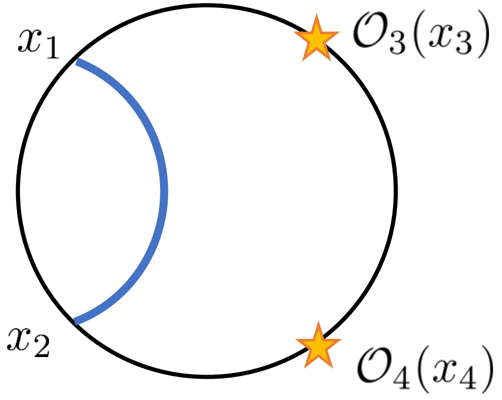

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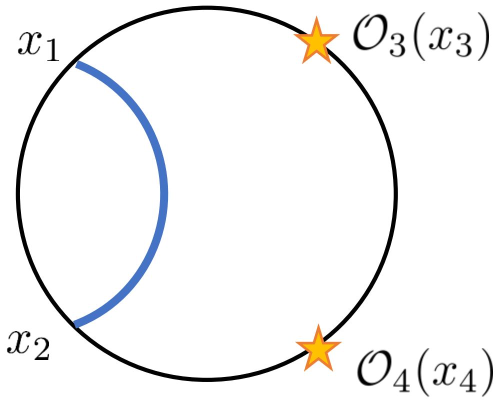

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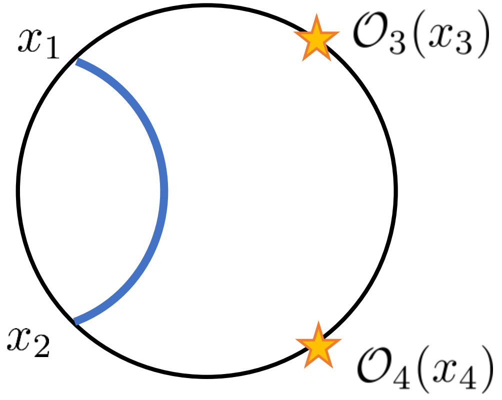

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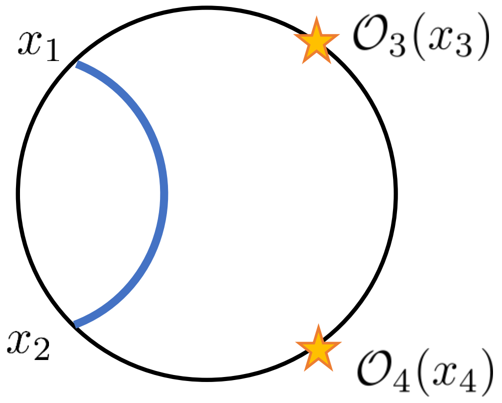

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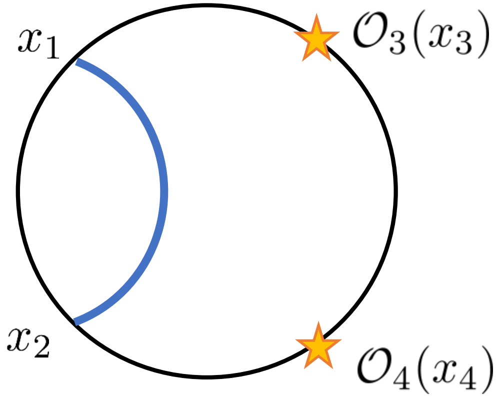

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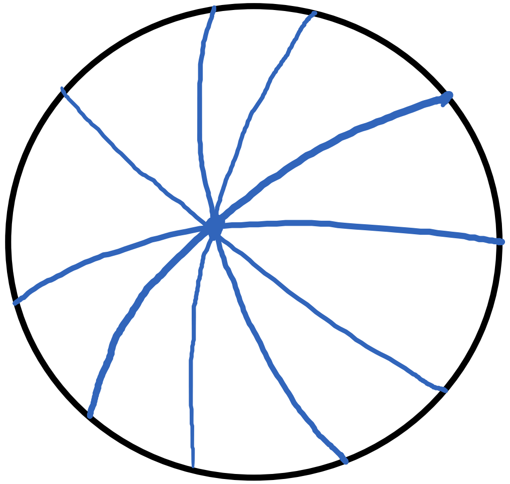

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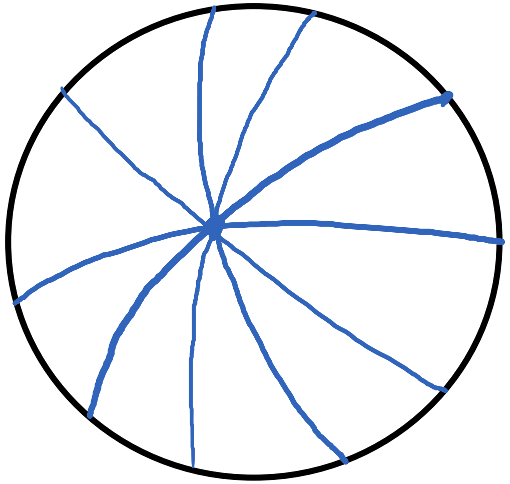

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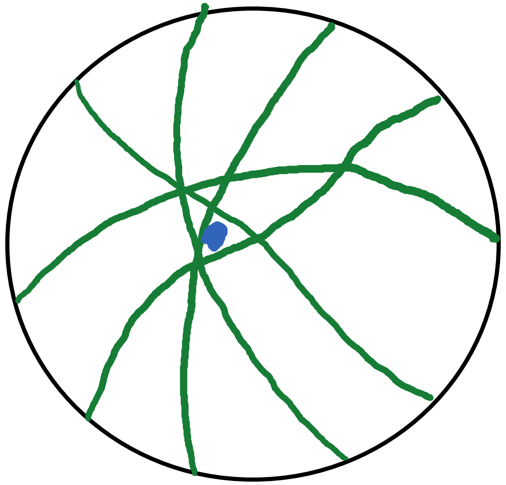

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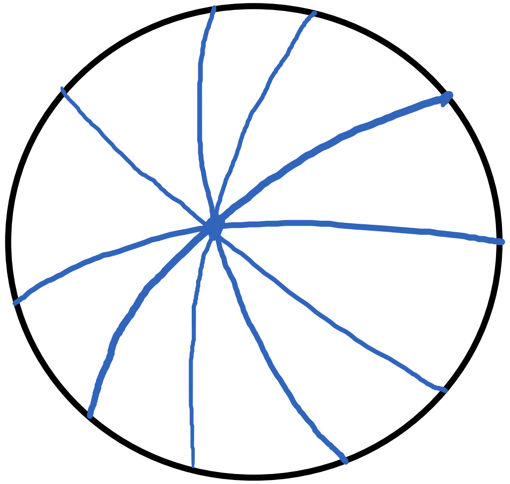

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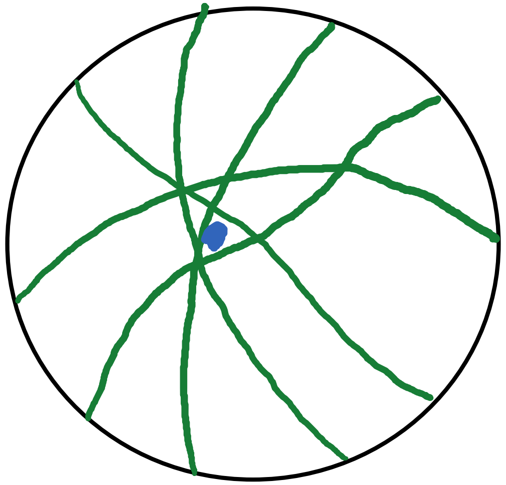

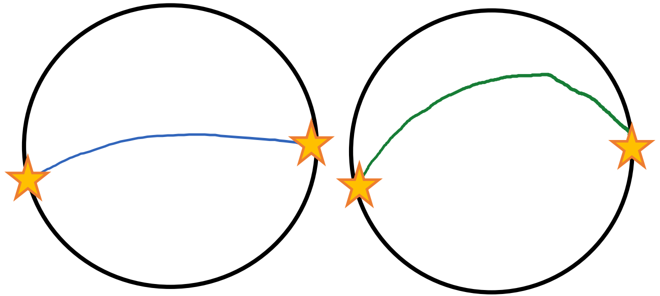

Geodesic operator simply defined in terms of boundary conditions in any state—background independent

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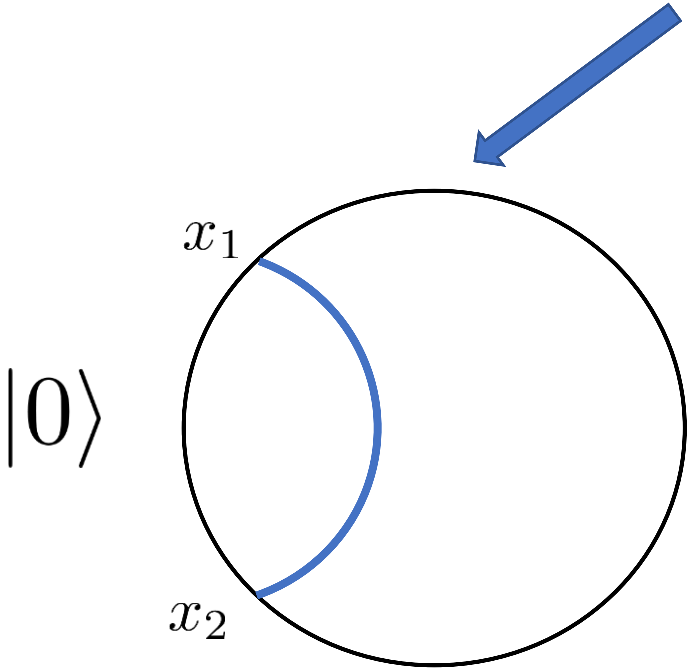

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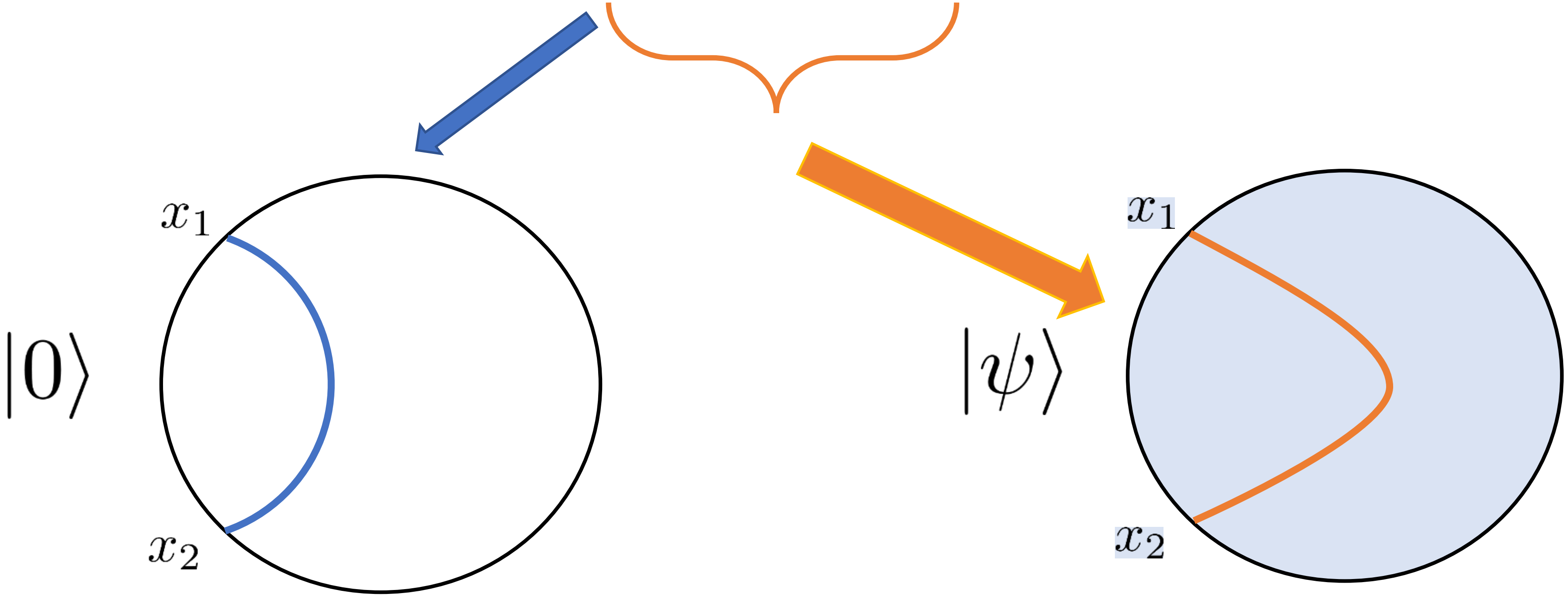

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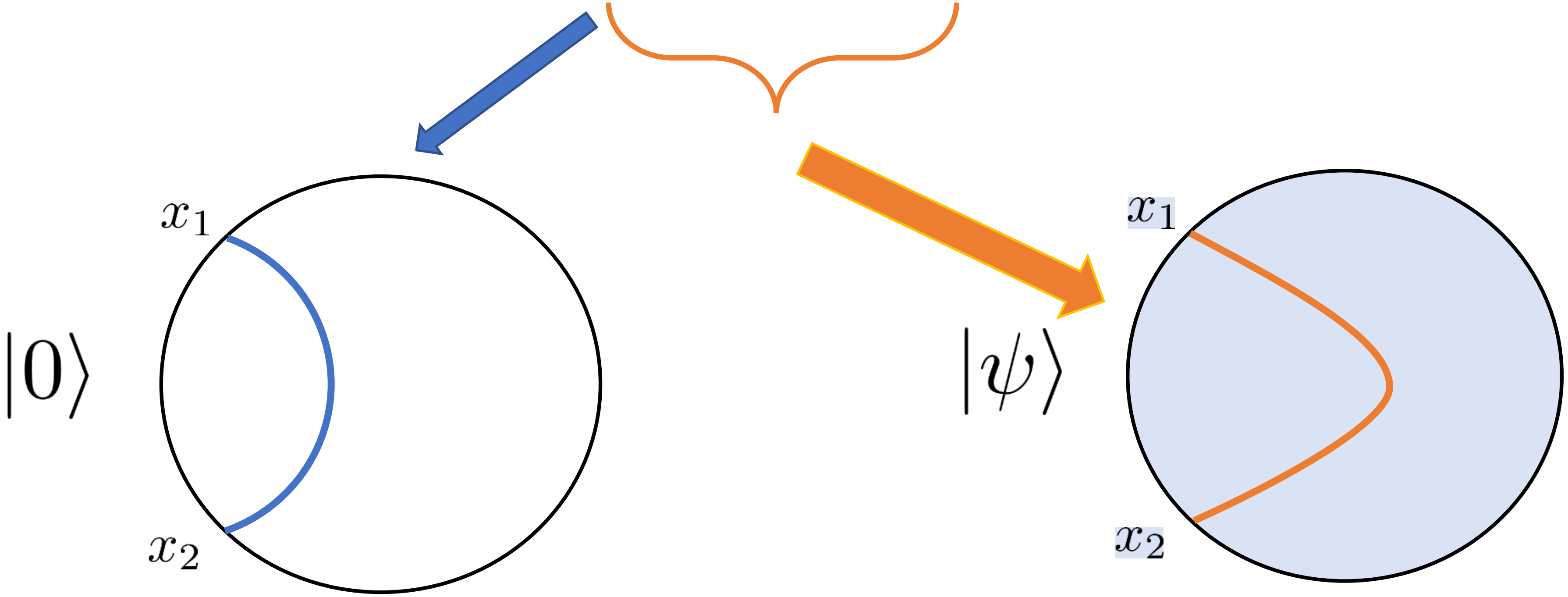

Resummation of operators in OPE → resummation of perturbative expansion.

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