

Boundary effects in quantum field theory

E.O.Y. Seminar
16th September 2026

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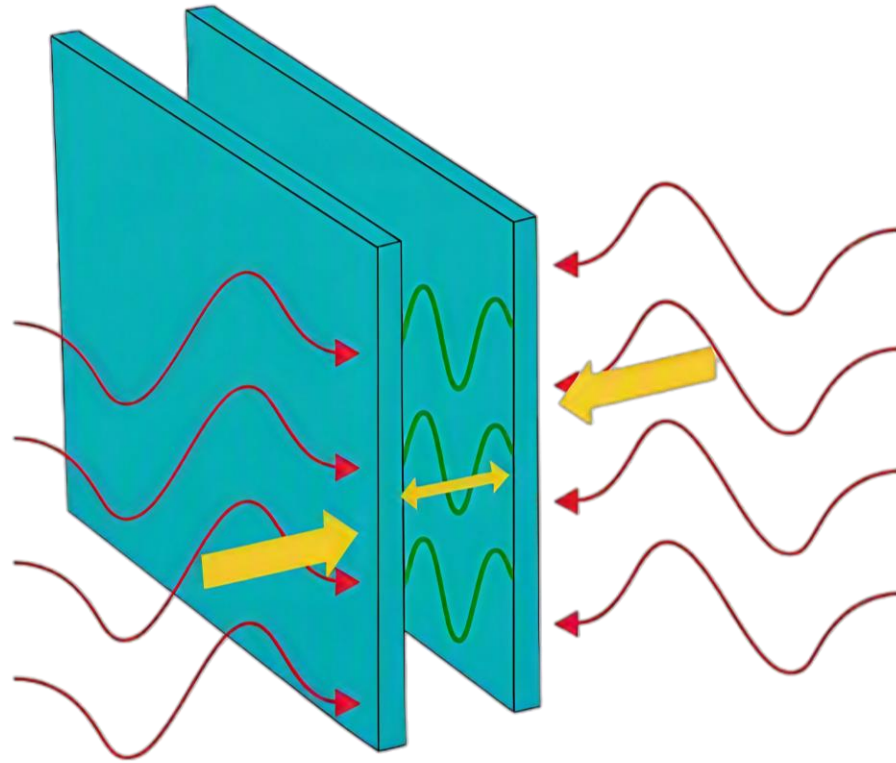
The background features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are primarily located on the right side of the frame, creating a modern, layered effect. The text is centered on the left side of the image.

**Why should we care
about boundaries?**

From Classical Physics...



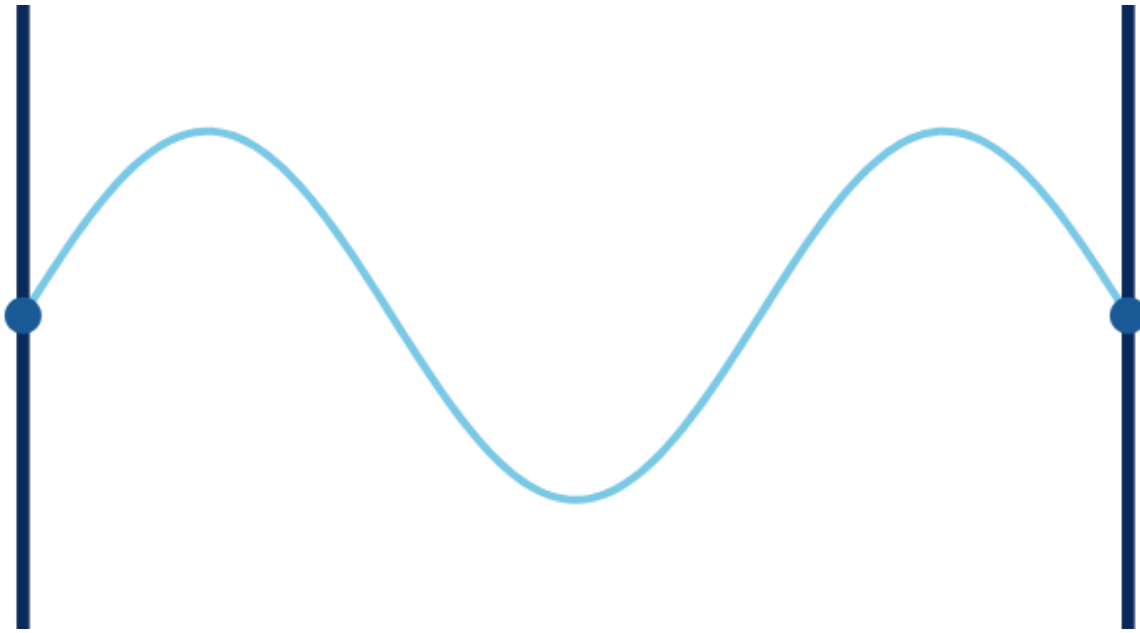
...to Quantum Field Theory



**How to model
a wave at the
boundary?**

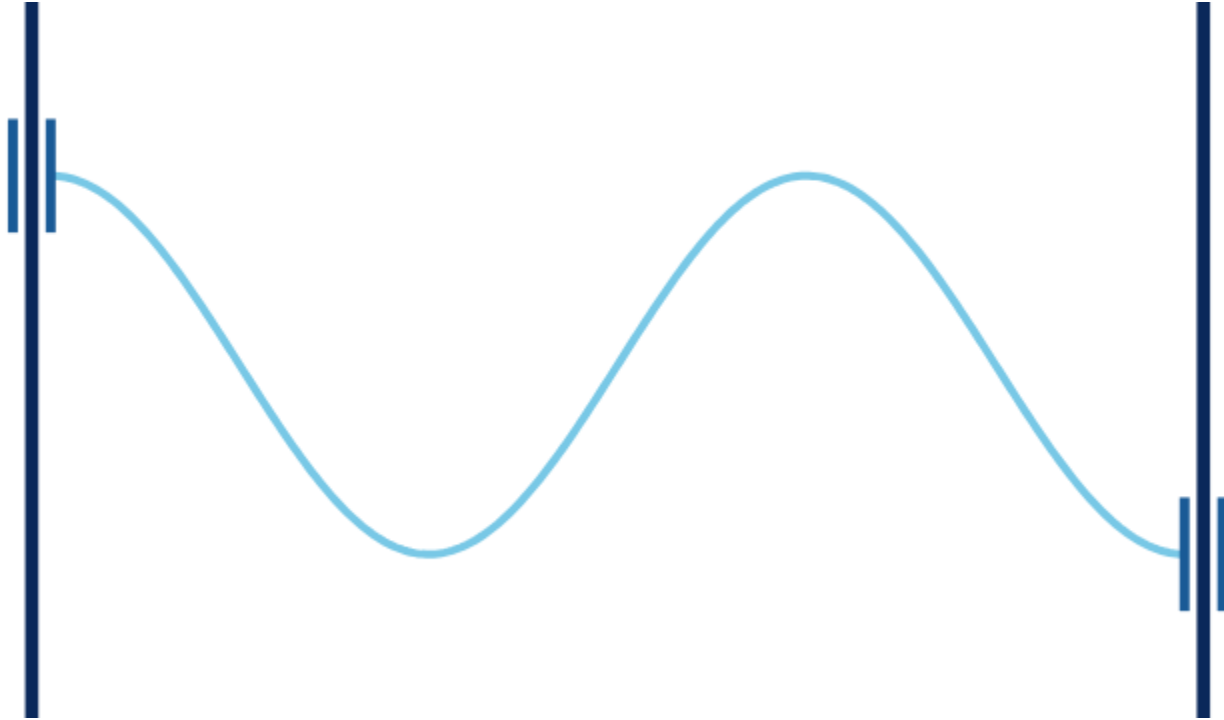


Dirichlet boundary conditions



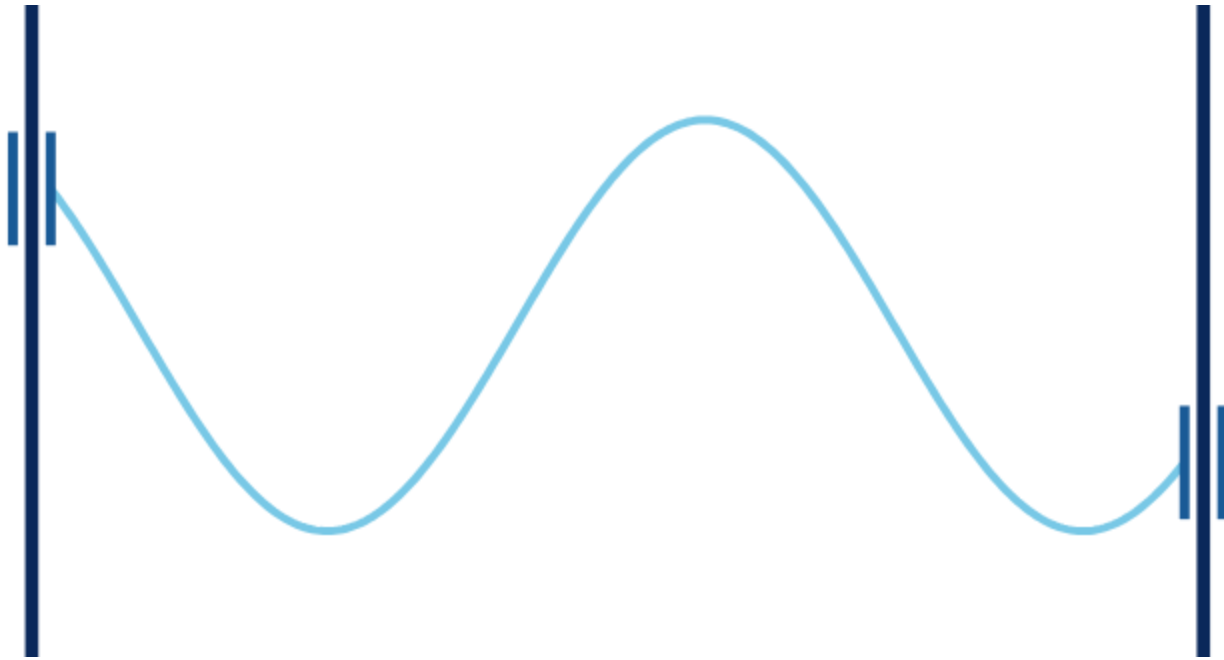
$$\Psi|_{\partial} = 0$$

Neumann boundary conditions



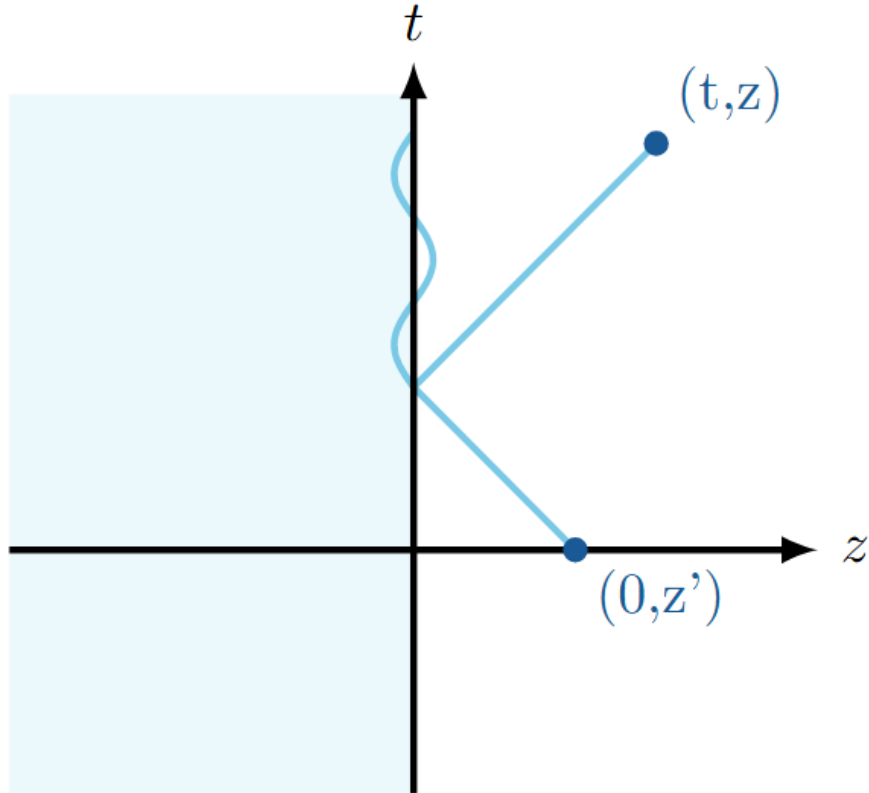
$$\nabla_n \Psi|_{\partial} = 0$$

Robin boundary conditions

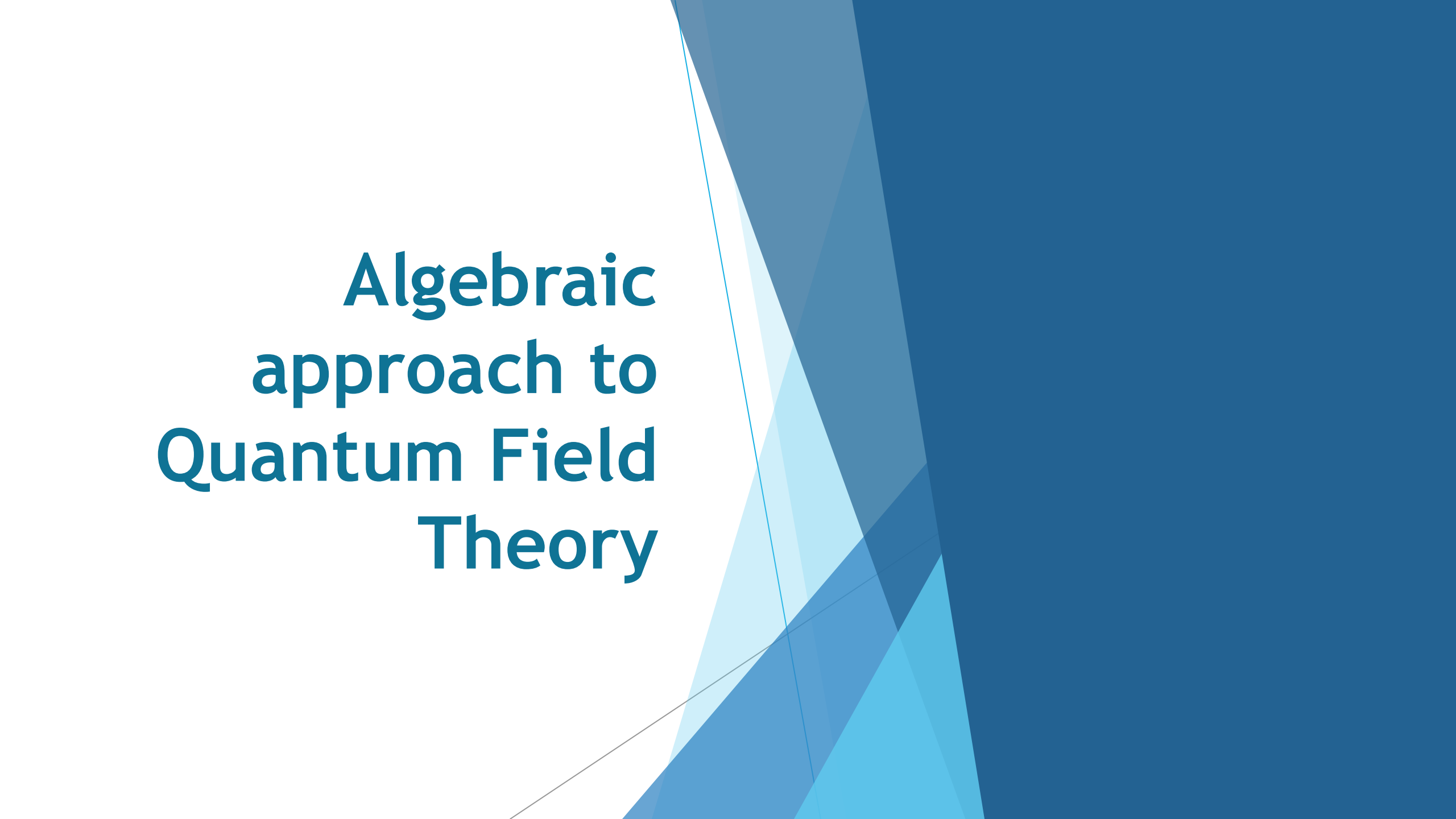


$$(\nabla_n \Psi + \kappa \Psi)|_{\partial} = 0$$

Klein-Gordon field on half-Minkowski



$$\begin{cases} (\square + m^2)\Psi = \Phi \\ \Psi|_{t=0} = \Phi_0 \\ \partial_t \Psi|_{t=0} = \Phi_1 \\ (\partial_z \Psi + \kappa \Psi)|_{z=0} = 0 \end{cases}$$



Algebraic approach to Quantum Field Theory

Goals

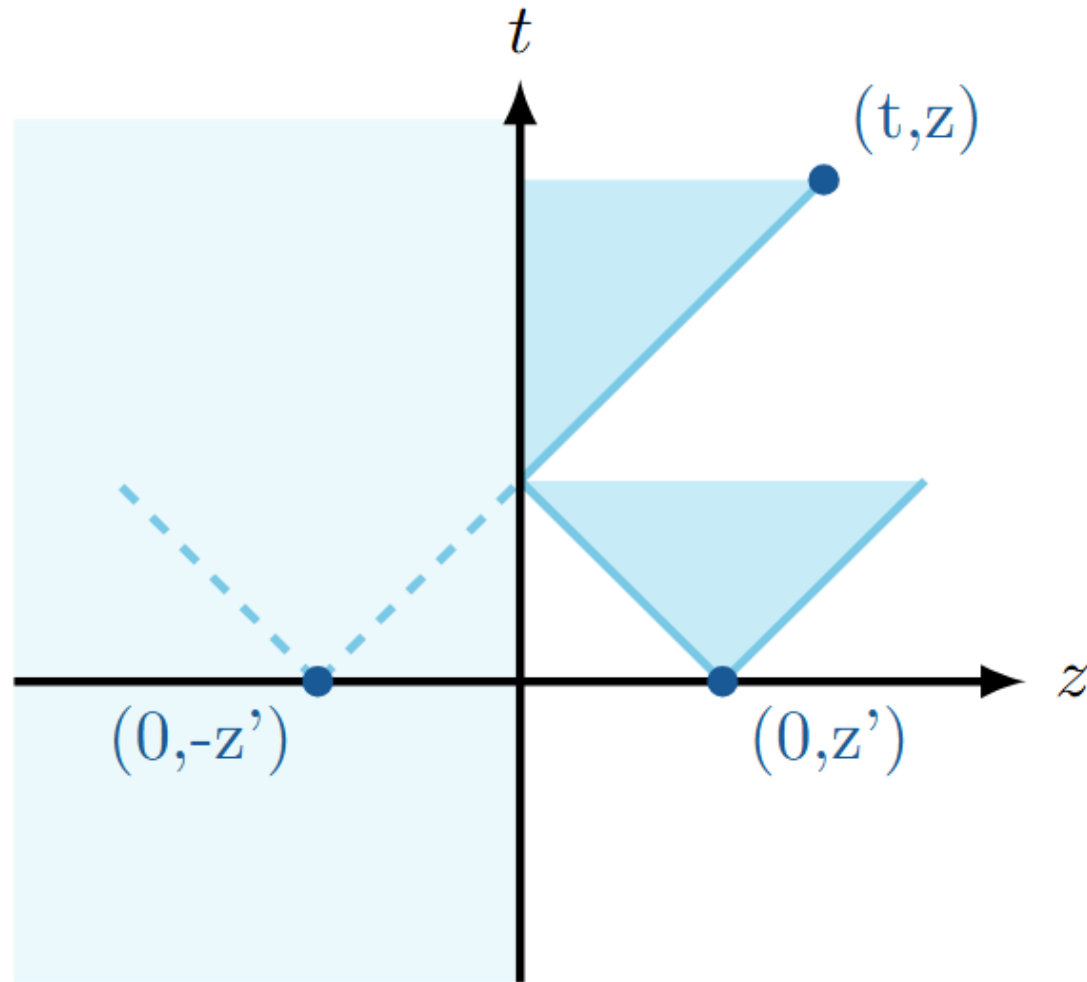
A black and white photograph of a cat's head and paw resting on a crumpled piece of paper. The cat is looking down at the paper with its mouth slightly open. The background is a blurred indoor setting.

**Fundamental
Solutions**

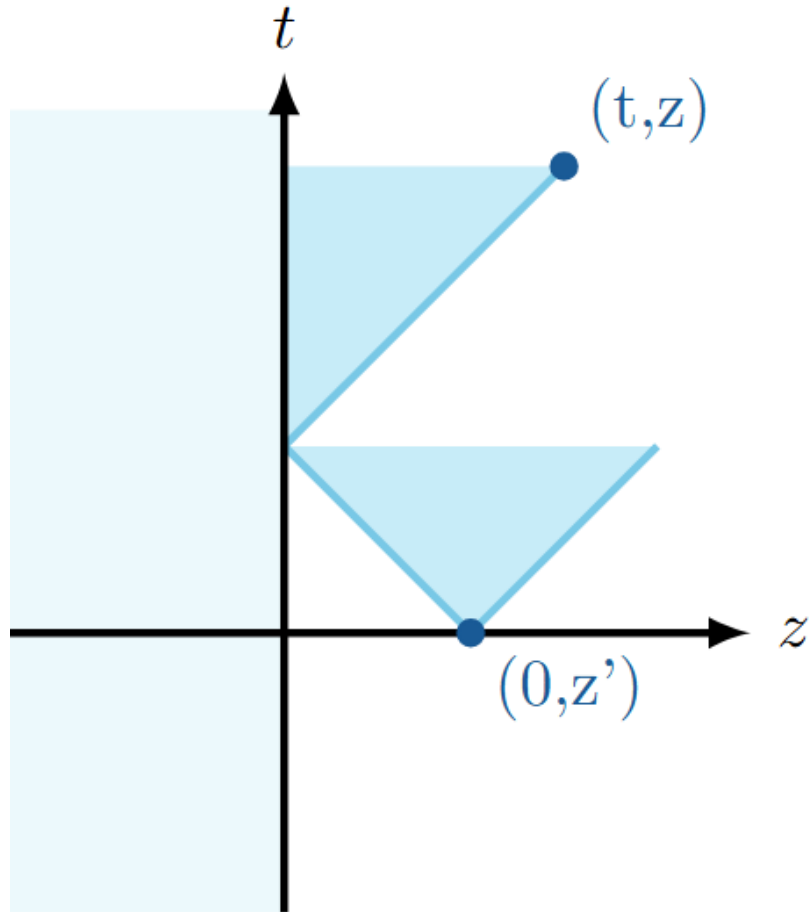
**Two-Point
Correlation
Function**

Part I: space of solutions - causality

Causality: Dirichlet/Neumann



Causality: Robin



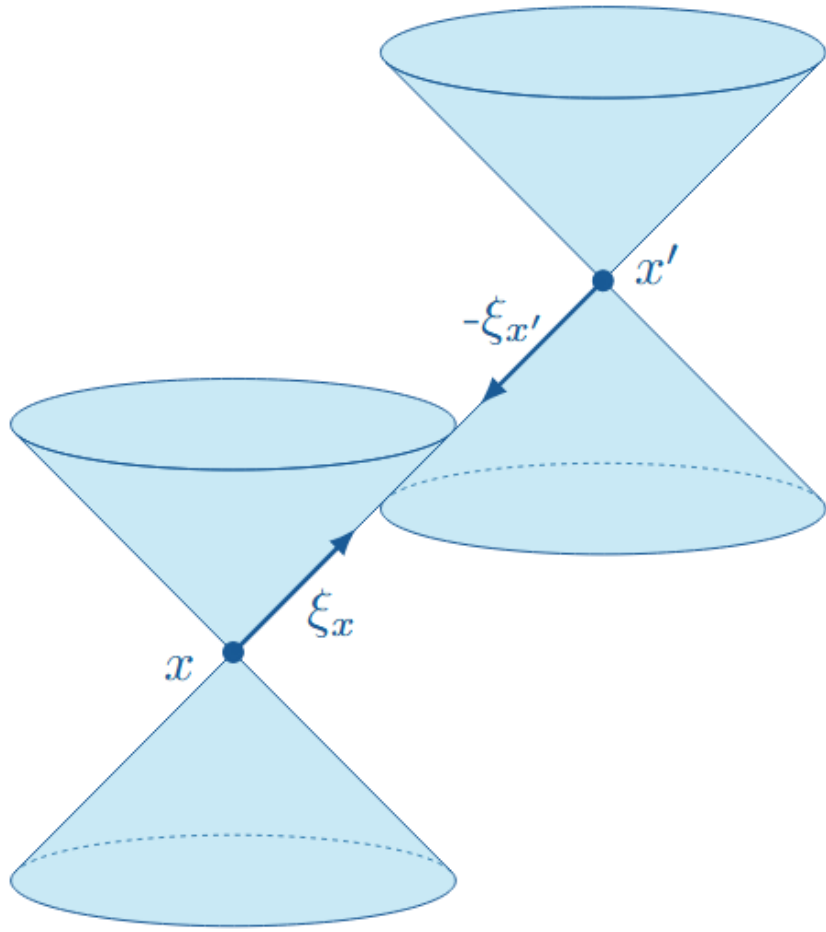
Proof by *mapping* the **Robin** problem into a **Dirichlet** one

Part II: two-point function



The *physically admissible* two-point functions guarantee that the *quantum fluctuations* of all observables are *finite*.





**Physical states
are Hadamard**

Robin two-point function - 4D

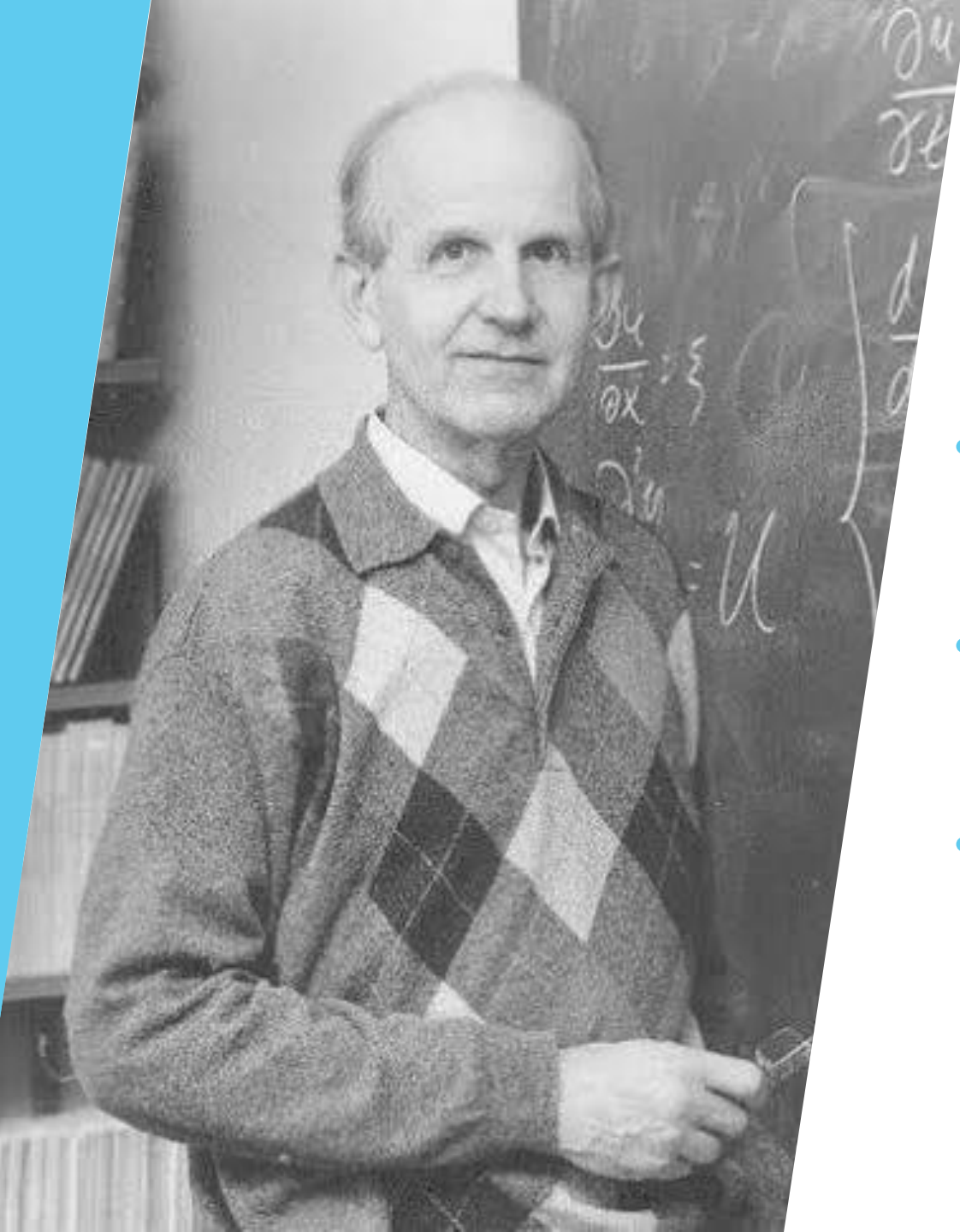
The *massless* Robin two-point function is

$$\omega_2 = \frac{1}{\sigma} + \frac{1}{\sigma_-} - \frac{2\kappa}{\sqrt{\sigma\partial}} e^{-\kappa(\sqrt{\sigma\partial} - z - z')}$$

Summary

For Robin boundary conditions

- Fundamental solutions are *causally supported*
- Two-point function abides by *Hadamard condition*



Outlooks

- *Curved* backgrounds with *timelike* boundary
- *(Asymptotically) Anti de-Sitter* spacetime
- *Singular geometries*, i.e., corners and edges