Effective quantum gravity from the point of view of perturbative algebraic QFT

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Outline of the talk

1. Algebraic approach to QFT
   - AQFT
   - LCQFT

2. Quantum gravity
   - Effective quantum gravity
   - Symmetries
   - Background independence

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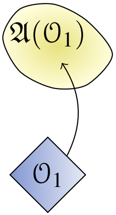

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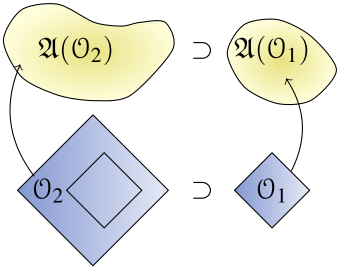
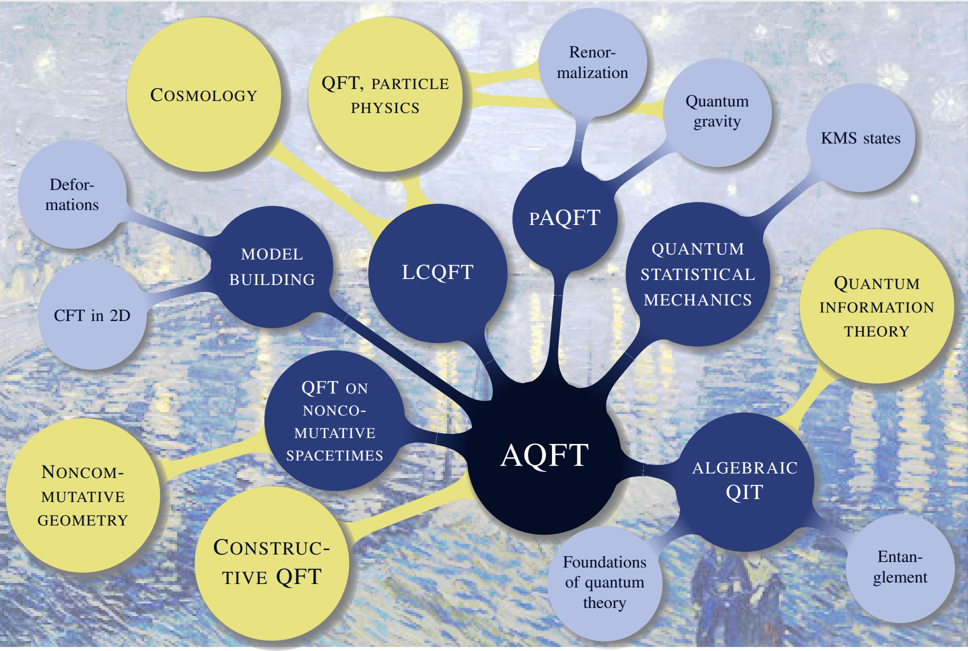
- The physical notion of subsystems is realized by the condition of isotony, i.e.: $\mathcal{O}_2 \supset \mathcal{O}_1 \Rightarrow \mathfrak{A}(\mathcal{O}_2) \supset \mathfrak{A}(\mathcal{O}_1)$. We obtain a net of algebras.



Different aspects of AQFT and relations to physics



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- Transition to imaginary times (Wick rotation) is possible only in special cases.
- Problems with the Fourier transform: calculations relying on momentum space cannot be performed.

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- Local features of the theory (observables) are separated from the global features (states).

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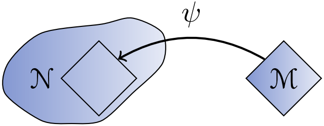

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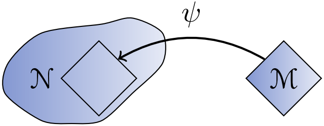

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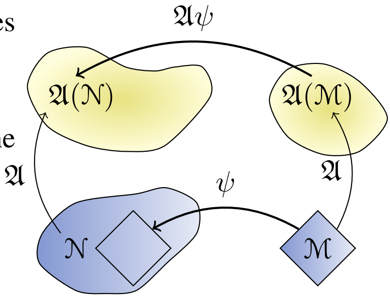
- Require that ψ preserves orientations and the causal structure (no new causal links are created by the embedding).
- Assign to each spacetime $\mathcal{M}$ an algebra $\mathfrak{A}(\mathcal{M})$ and to each admissible embedding ψ a homomorphism of algebras $\mathfrak{A}\psi$ (notion of subsystems). This has to be done covariantly.



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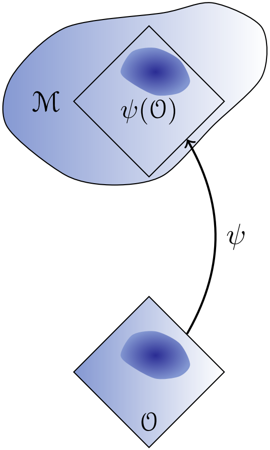

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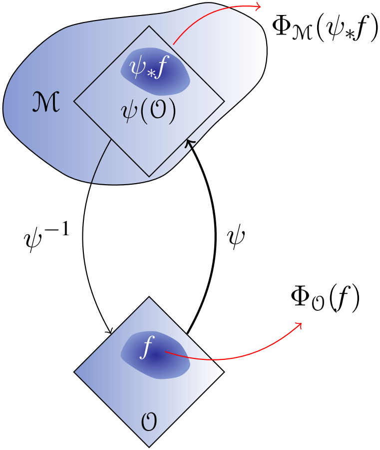

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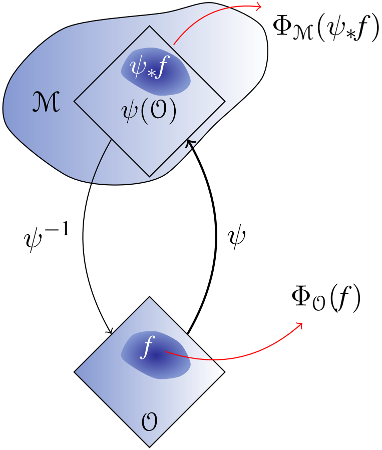

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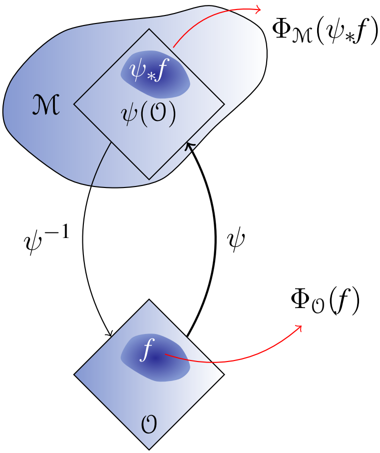
- Locally covariant fields are candidates for observables in GR.



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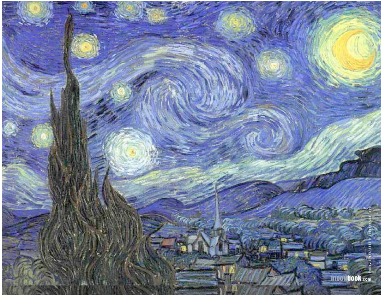

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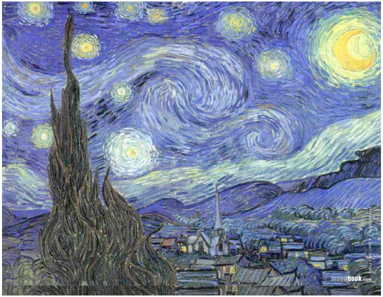

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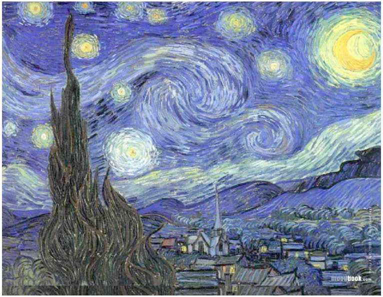
- As a QFT, quantum gravity is power counting non-renormalizable.



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- **Dynamical nature of spacetime**: make a split of the metric into background and perturbation, quantize the perturbation as a quantum field on a curved background, show background independence at the end.
- **Diffeomorphism invariance**: use the BV formalism to do the gauge fixing. Possible difficulties: base manifold is Lorentzian and non-compact, symmetry group is infinite dimensional, so is the space of metrics.

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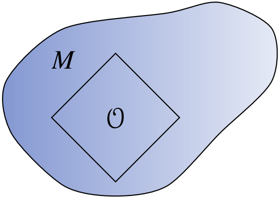

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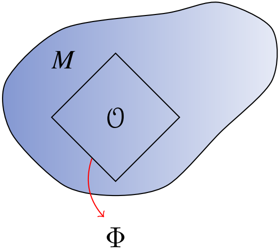

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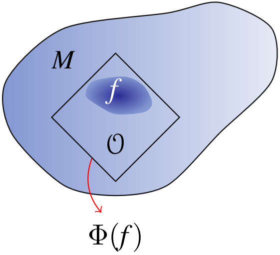

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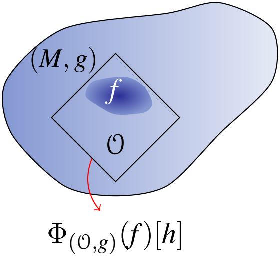

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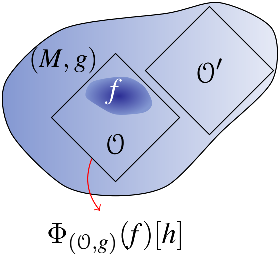
- Diffeomorphism transformation: move our experimental setup to a different region $\mathcal{O}'$.



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- Next, we use the deformation quantization to construct the non-commutative quantum algebra.
- We work all the time on the same set of functionals, but we equip it with different algebraic structures (i.e. Poisson bracket, non-commutative $\star$ product).

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- Example: $\int R[g+h] f \, d\mu_{g+h}$ is diffeomorphism invariant, but $\int R[g+h] f \, d\mu_g$ is not.

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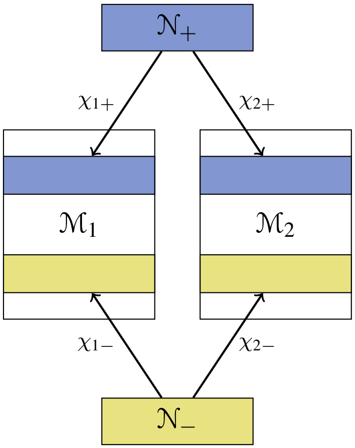
- Each $\Phi_{\boldsymbol{f}}$ induces a relational observable $g \mapsto \Phi_{\boldsymbol{f}}(h, X_{g+h})$.

Relative Cauchy evolution

- Let $\mathcal{N}_+$ and $\mathcal{N}_-$ be two spacetimes that embed into two other spacetimes $\mathcal{M}_1$ and $\mathcal{M}_2$ around Cauchy surfaces, via admissible embeddings $\chi_{k,\pm}, k = 1, 2$.



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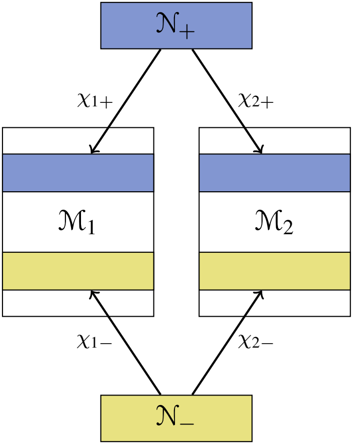
- Then $\beta = \mathfrak{A}\chi_{1+} \circ (\mathfrak{A}\chi_{2+})^{-1} \circ \mathfrak{A}\chi_{2-} \circ (\mathfrak{A}\chi_{1-})^{-1}$ is an automorphism of $\mathfrak{A}(\mathcal{M}_1)$. This is the consequence of the Time-slice axiom of LCQFT.



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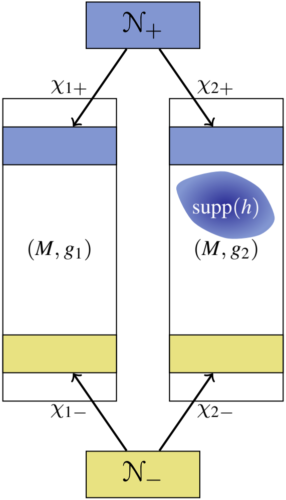

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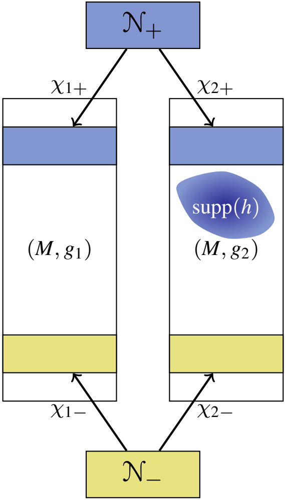

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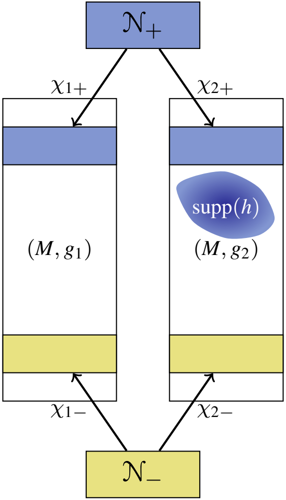

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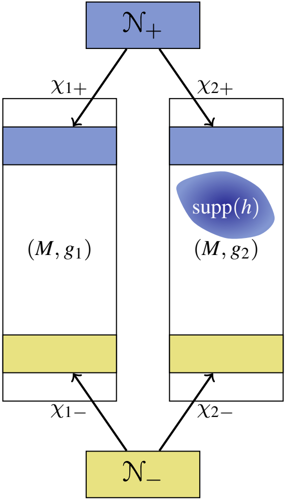
- We have proven that this condition is fulfilled as a consequence of quantized Einstein's equations.



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- We have shown that our theory is background independent, i.e. independent of the split into free and interacting part.

Thank you for your attention!