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Lecture 3: The Galileo principle for general dynamical systems: Lorentz transformations from Quantum Theory and a little bit more (homogeneity, isotropy, and locality)

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Free Quantum Field Theory (QFT) can be derived without quantization rules as a quantum ab initio theory of numerable systems, with general assumptions as homogeneity, isotropy, locality and linearity of the interactions. What follows is a theory of quantum walks on the Cayley graph of a group G. Virtually abelian G corresponds to QFT in Euclidean space, whereas relaxing linearity leads to interacting QFTs. The purely mathematical adimensional theory contains the standards for mass, space, and time through the nonlinearities intrinsic to the theory (maximum wave-vector, frequency, and mass, the latter from unitarity). The small wave-vector regime connects these standards to the speed of light and to the Planck constant, whereas at the maximum value for the particle mass the dispersion relation becomes flat, with interpretation as a mini-black hole, thus setting the scale at Planck's. The Galilean relativity principle can be semantically translated for a general dynamical system, and for the case of a quantum walk it corresponds to the invariance of the walk with the representation. The Lorentz transformations make a nonlinear group (the theory is a model for doubly special relativity), whereas the usual linear transformation are recovered in the small wavevector regime, corresponding to the whole physical domain experimented so far. The particle is still the Poincaré invariant. A new emerging feature is that for Planckian boosts/masses also the rest-mass get involved in the transformations, leading to a De Sitter covariance.

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