MP 18: Constructive Tools for Quantum Field Theory

Time: Friday 11:00–12:15 Location: H6

MP 18.1 Fri 11:00 H6

A product picture for quantum electrodynamics — •Bernard Kay — Department of Mathematics, University of York, York, England

We exhibit a product picture for QED – i.e. a reformulation in which it has a total Hamiltonian, arising as a sum of a free electromagnetic Hamiltonian, a free Dirac Hamiltonian and an interaction term, acting on a Hilbert space which is a subspace (the "physical subspace") of the full tensor product of an electron/positron Hilbert space and an electromagnetic-field Hilbert space. The traditional Coulomb-gauge formulation of QED isn't a product picture in this sense because, in it, the longitudinal part of the electric field is a function of the Dirac ψ-field. We prove (at a formal level) our product picture is equivalent to Coulomb gauge QED. Also, in the product picture: (i) In all states in the physical subspace, the ψ field is entangled with longitudinal photons; (ii) Gauss's law holds as an operator equation; (iii) The electric field operator and the full Hamiltonian aren't self-adjoint on the full tensor-product Hilbert space, but they are self-adjoint on the physical subspace and so that's OK. Also (iv) The product picture resembles temporal gauge quantization but seems free from the well-known difficulties of that; (v) In the nonrelativistic limit, one obtains a reformulation of Schroedinger many body theory in which the usual Coulomb potential is absent and, instead, a term representing the kinetic energy of longitudinal photons is present so that, say, the binding energy of the Hydrogen atom is seen to arise as a byproduct of the entanglement of the proton and electron with longitudinal photons.

MP 18.2 Fri 11:25 H6

Quantum field theory without ghosts and indefinite metric – A program and some results. — •Jens Mund — Departamento de Fisica, Universidade Federal de Juiz de Fora, Brazil

Quantum field theories involving interacting vector fields with spin/helicity one (or higher) are usually based on gauge theory: One adds unphysical degrees of freedom in the form of "negative norm" states and "ghost" fields before the construction, and divides them out afterwards by requiring gauge (or BRST) invariance of the S-matrix and of observable fields. The construction of charge-carrying fields (like the Dirac field in QED) is notoriously difficult.

In the talk an alternative approach is presented: Instead of Hilbert space positivity, the localization of (unobservable) fields is weakened, in a way permitted by the principles of relativistic quantum field theory: The fields are localized on "Jordan-Mandelstam strings" extending to space-like infinity. They act in a true Hilbert space without ghosts. In contrast to gauge theory, our approach allows for a direct (perturbative) construction of charged interacting fields. I comment on partial results on (massive and proper) QED, (Abelian) Higgs model, and Yang-Mills models.

MP 18.3 Fri 11:50 H6

Renormalization in string-localized quantum field theory — •Christian Gass — Universität Göttingen, Germany

String-localized quantum field theory (SL QFT) provides an alternative to the usual gauge theoretic approaches. In the last one-and-a-half decades, many conceptual benefits of SL QFT have been discovered. However, a renormalization recipe for loop graphs with internal SL fields was not at hand until now.

In this talk, we present a proof that the problem of renormalization is not worse in SL QFT than in usual point-localized theories. This happens in spite of the analytic complexity of SL propagators and provided that one takes care in how to set up perturbation theory in SL QFT. Consequently, renormalization stays a pure short-distance problem and the improved short-distance behavior of SL fields remains a meaningful notion, which indicates that there can exist renormalizable models in SL QFT whose point-localized counterparts are non-renormalizable.