

Examination topics of
Mathematical Introduction to QFT
Winter Semester 2021/22

1. Joint spectrum of the energy-momentum in relativistic quantum mechanics
2. Green's function of the Helmholtz equation.
3. Retarded, advanced and Pauli-Jordan propagator of the Klein-Gordon equation.
4. Feynman/anti-Feynman propagators and the positive/negative frequency 2-point functions of the Klein-Gordon equation.
5. Various propagators and 2-point functions of the (massless) wave equation in 1+3 dimensions.
6. Tensor product of Hilbert spaces. Fock spaces.
7. Creation/annihilation operators—rigorous definition and commutation relations.
8. Operators $\Gamma(\cdot)$ and $d\Gamma(\cdot)$ in the second quantization.
9. From the Hamiltonian to Lagrangian formalism and back.
10. Representations of canonical commutation relations and the Stone-von Neumann Theorem.
11. Free scalar field in the Lagrangian and Hamiltonian formalism.
12. Quantum free scalar bosons and their 2-point functions (commutator, non-time-ordered and time-ordered).
13. Comparison between the neutral and charged free scalar bosons.
14. $*$ algebras and their representations, especially in finite dimension.
15. Haag-Kastler axioms of QFT.
16. Wightman axioms of QFT.
17. Dynamics generated by time-dependent Hamiltonians and the scattering operator.
18. Gaussian integral in several dimensions.
19. Generating functions of a symplectic transformations and the integral kernel of operators implementing symplectic transformations.

20. Path integrals for quadratic Hamiltonians.
21. Scalar field with a mass-like perturbation in the Lagrangian and Hamiltonian formalism.
22. The renormalization of the vacuum energy for a mass-like perturbation.