UCBL and ENS Lyon
2023-2024
Alessandra Frabetti

Advanced Mathematics Master 2nd year
Program in Mathematical Physics
http://math.univ-lyon1.fr/homes-www/frabetti/M2-2024/

Quantum Field Theory and Renormalization

0. Introduction

- From macro to micro scale, matter and forces, particles and fields
- Fermions and bosons, Standard Model

1. Review of classical field theory

- Matter fields as sections of vector and spinor bundles
- Dynamics requires spin connection plus minimal coupling to gauge bosons
- Least action principal and Euler-Lagrange equation
- Free fields and propagators
- Interacting fields, perturbative solution with tree-Feynman diagrams

2. Quantum field theory

- Quantization: canonical, deformation quantization, statistical
- Path integrals in QM and in QFT
- Correlation functions, partition function, Dyson-Schwinger equation
- Computation for free fields
- Computation for interacting fields, Feynman rules
- Feynman rules on momentum space, 1PI graphs

3. Renormalization

- Divergencies in Feynman graphs (vs multiplication of distributions)
- Renormalisable theories
- Power counting and Bogoliubov's subtraction scheme for 1-loop divergencies
- Subdivergencies and BPHZ formula for many loops divergencies
- Dyson's renormalization formulas, renormalized Lagrangian and renormalization factors

4. Renormalization Hopf algebras

- Proalgebraic groups and their representative Hopf algebras
- Connes-Kreimer renormalisation Hopf algebra
- Proalgebraic renormalisation groups of diffeographisms and formal diffeomorphisms.

References: http://math.univ-lyon1.fr/homes-www/frabetti/M2-2024/references/