Renormalisation of QED

Ecole Doctorale Grenoble 2011

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LPSC/UJF

Organisation

- 6 x 2 hours, Black board, in English
- Contact:

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- First lecture (date,time): → Doodle Pool
  (need e-mail adresses)

Prerequisites

- Basic knowledge of QED
  (will be briefly reminded)
- Basic knowledge of Feynman rules
  (will be briefly reminded)

Literature

- **This lecture follows mostly:**
  - M. Steinhauser, Übungen zu Strahlungskorrekturen in Eichtheorien, Herbstschule für Hochenergiephysik, Maria Laach 2003 (in German)
- **General textbooks on QFT:**
  - J. Collins, Renormalization, Cambridge University Press
  - M. Kaku, Quantum Field Theory, Oxford Univ. Press
  - M. Peskin, D. Schroeder, Quantum Field Theory, Addison Wesley
  - J. D. Bjorken, S. D. Drell, Relativistic Quantum Mechanics
  - S. Pokorski, Gauge Field Theories, Cambridge Univ. Press
  - ...

- **Specialised textbooks:**
  - V. A. Smirnov, Feynman Integral Calculus, Springer
  - M. Abramowitz, I. Stegun, Handbook of Mathematical Functions
- **More references to the original literature and textbooks will be given during the lectures**

Plan

1. **Preliminary remarks**
2. **Elements of QED**
   - Lagrangian density
   - Feynman rules
3. **Loop corrections: General considerations**
   - Power counting
   - Vertex functions
     - Photon self energy at one-loop
     - Electron self energy at one-loop
     - Vertex correction at one-loop
   - Regularization

4. Techniques for (one-)loop calculations

- One-loop tensor integrals in n dimensions: General definition
- Calculation of scalar one-loop integrals
  - Special functions
  - Parameter integrals, Shift of loop momentum, Wick rotation
  - Master formula
- Examples/Application of the master formula
  - Scalar one-point function
  - Scalar two-point function
  - Scalar three-point function
- Calculation of tensor integrals
- Master formula in n=4 with UV-cutoff Λ ***
- New methods (IBP, Differential Equations) ***

5. Renormalisation of QED

- Multiplicative renormalization
- Feynman rules for counter terms
- Renormalization conditions
  - Renormalized AA-Vertex
  - Renormalized ēe-Vertex
  - Renormalized eeA-Vertex
- Renormalization constants

6. The renormalisation group

- Group structure
- The renormalisation group equation (RGE)
- Beta function of QED
- Running alpha