Particles and gravity I
-the lecture program-

1. Brief introduction to classical field theory:
   - Special relativity ([1] sec. 2)
   - The variational principle and the Lagrange formulation of a classical field theory
   - Electrodynamics and gauge invariance (gauge fixing) ([1] sec. 2)
   - The Klein-Gordon field
   - The Dirac field
   - Yang-Mills theories
   - The Noether's theorem for internal symmetries and space-time translations
   - The energy-momentum tensor for the electromagnetic, the Klein-Gordon and the Dirac field
2. Basics of quantum field theory:
   - Path integrals: from quantum mechanics to fields and particles, propagator for massive scalar and vector fields [2]
   - Attraction v.s. repulsion ([2] sec. 1.4-1.6):
     - classical potential for scalar-, vector-mediated interactions
     - propagator for massive spin 2 particle a la Veltman [2, 7] and the classical potential for an exchange of spin 2 quanta
3. Gravity as a field theory:
   - Gravity as a theory of spin 2 gravitons described by a symmetric second rank tensor, construction of the kinetic part of the Lagrangian ([3] sec. 3)
   - Field equations for massless gravitons, gauge invariance ([3] sec. 3) and the path quantization in the harmonic gauge
   - Propagator for massless gravitons ([2] sec.VIII.1)
   - The Lagrangian and the propagator for massive gravitons (the Fierz-Pauli model)

- The deflection of light by massless and massive gravitons and the van Dam–Veltman–Zakharov discontinuity

4. The General Relativity

   - The principle of equivalence ([1] sec. 3.1-3.4)
   - The principle of general covariance ([1] sec. 4.1)
   - Curvilinear coordinates and the tensor analysis ([1] sec. 4.2-4.7, [4] sec. 83, 85)
   - The general covariance v.s. local gauge invariance ([1] sec. 4.10)
   - The curvature ([1] 6.1-6.2, 6.6, [4] sec. 91, 92)
   - The Einstein's field equations ([1] 7.1) and the Lagrangian formulation of the General Relativity ([1] sec. 12.1-12.4, [4] sec. 93, 95 and [9] appendix E1)
   - Conformal transformations and invariance of the Klein-Gordon and Maxwell equations ([9] appendix D)

5. Experimental tests of the General Relativity

   - The Newtonian gravity as a limit of the General Relativity ([1] sec. 3.4, 9.1, [4] sec. 96, [10] sec. 11.8)
   - Deflection of light ([1] sec. 8.5)
   - Short distance tests of the Newtonian gravity ([6])

6. Particles in a curved spacetime:

   - Effects of gravitation for a material particle and the electromagnetic field ([1] sec. 5.1-5.3)
   - The "minimal substitution rule", the Klein-Gordon field and the electromagnetic field in the General Relativity ([9] appendix E1, [3] sec. 10.2, 10.3, 16.1)
   - Fermions in a gravitational field

7. Perturbation expansion and Feynman rules

   - Expansion of the gravitational action around a background gravitational field and the gauge invariance of gravitation ([11], [1] sec. 10.1, [2] sec. VIII.1)
   - Quantization and graviton interaction vertices ([7], [8], [2] sec. VIII.1)
   - Graviton polarization tensors and the angular momentum content of massless and massive graviton ([3] sec. 3.2-3.4, [12])

Literatura

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