8. EXERCISE SHEET: QUANTUM FIELD THEORY

Aufgabe 18:

(a) Compute the 2-point correlator in ϕ^3 theory, $\mathcal{H}_{\rm I} = \frac{g}{3!}\phi^3$ to order g^2. It suffices to list the result as a sum of contractions. You can also assume that the field has zero vacuum expectation value $\langle 0|\phi|0\rangle = 0$. Also represent the result diagrammatically.

(b) Compute the 3-point correlator in ϕ^3 theory as the sum of all connected diagrams to order g^5 (again for $\langle 0|\phi|0\rangle = 0$). A representation in terms of diagrams is sufficient.

Aufgabe 19:

Besides differential cross sections, decay rates Γ of unstable particles are an important observable in particle physics. In direct analogy to cross sections, also the (differential) decay rates are related to transition matrix elements.

Let M be the rest mass of a decaying particle and p_f the 4-momenta of the outgoing decay products. Then the differential decay rate is given by

$$d\Gamma = \frac{1}{2M}\left(\prod_f \frac{d^3p_f}{(2\pi)^3}\frac{1}{2E_f}\right)|\mathcal{M}(M\to\{p_f\})|^2(2\pi)^4\delta^{(4)}(p_M-\sum p_f),$$

where p_M is the 4-momentum of the decaying particle.

Now consider the decay of a heavy real scalar particle Φ with mass M into two light real scalar particles χ with mass m ($M > 2m$) mediated by the interaction

$$\mathcal{H}_I = g\Phi\chi^2.$$

Compute the life time (inverse decay rate) to lowest order in g.