

1 Feynman Diagrams

Lecture 13 –
20.05.2022

1.1 Wick's Theorem

In the previous section, the *Kubo formula* was introduced. Higher order correlation functions get introduced in the effort of calculating non-equilibrium properties of interest, for example $\rho * \rho$ has field operators in order 4. Wick's theorem gives a path to deal with those.

The goal is to factorize multi-particle correlation functions (as in, creating/annihilating multiple particles) into single particle correlation functions (creating/annihilating one particle), everything for non-interacting systems.

The starting point is a general, non-interacting Hamiltonian:

$$H_0 = \sum_{\nu, \nu'} h_{0, \nu \nu'} c_{\nu}^{\dagger} c_{\nu'} . \quad (1.1)$$

Lecture 16 –
13.06.2022

1.2 Diagrammatic Perturbation Theory

The starting point for developing diagrammatic perturbation theory is the Matsubara green function

$$G_{\alpha\beta}(\tau) = - \left\langle T_{\tau} c_{\alpha}(\tau) c_{\beta}^{\dagger}(0) \right\rangle \quad (1.2)$$

with operators in Heisenberg representation, i.e.

$$c_{\tau} = e^{\tau H} c_{\alpha} e^{-\tau H} . \quad (1.3)$$

We assume a very general Hamiltonian of the form

$$H = H_0 + V \quad (1.4)$$

with a non-interacting part H_0 and the interaction/perturbation V .