PHY-MV-FN-T34 – Quantum field theory for correlated many particle systems

Lecture held winter term 2022/23 by Dr. Georg Rohringer, Universität Hamburg

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Contents

1 Introduction to many-body systems and mean field theories

1.1 Revision of many-body physics

Lecture 1, 19.10.2022

In undergraduate quantum mechanics, two kinds of problems are always addressed (here for the special case of electrons in an electro magnetic field):

One-body problem:
Two-body problem:
Many-body problem:

1.2 Quantum-mechanical and statistical description of non-interacting many-body systems

Lecture 2, 20.10.2022

1.2.1 Quantum Mechanics

We construct an N -particle Hilbert space as the tensor product of N single-particle Hilbert spaces:

$$\mathcal{H}_N = \mathcal{H}_1^{(1)} \otimes \ldots \otimes \mathcal{H}_1^{(N)} \tag{1.1}$$

A Hamiltonian in a Hilbert space like that consists of a sum of single-particle Hamiltonians:

$$H_N = H^{(1)} + \ldots + H^{(N)} \tag{1.2}$$

Strictly speaking, each Hamiltonian has the form

$$\mathbb{1}^{(1)} \otimes \ldots \otimes H^{(i)} \otimes \ldots \otimes \mathbb{1}^{(N)}\,, \tag{1.3}$$

where $\mathbb{1}^{(j)}$ is the identity acting in the j-th single-particle Hilbert space and $H^{(i)}$ is the Hamiltonian acting in the i-th single particle Hilbert space.