1 Introduction to quantum many-body systems

1. The expansion of the many-body wave function into single-particle orbitals.
2. Second-quantization formalism: Fock space and creation/annihilation operators.
3. Second-quantization formalism: one-body and two-body operators.
4. The jellium Hamiltonian, density and current operators.
5. Canonical transformations to diagonalize non-interacting fermionic models.
6. Canonical transformations to diagonalize non-interacting bosonic models.
7. The many-body problem in presence of two-body interactions.
8. The unrestricted Hartree-Fock approximation for fermionic models.
9. The Hartree-Fock approximation for fermionic models as a mean-field theory.
10. The single-orbital Hubbard model for fermions and bosons.
11. Symmetries of the Hubbard model. Spin operators for the fermionic case.
12. The fermionic Hubbard model: limiting cases ($U = 0$ and $t = 0$).
13. The two-site Hubbard model: the super-exchange energy.
14. The strong-coupling expansion: The Heisenberg model (and its generalizations).
15. The Hartree-Fock approximation for the Hubbard model at half filling.
16. The Gutzwiller wave function and the Gutzwiller approximation (I).
17. The Gutzwiller wave function and the Gutzwiller approximation (II).
18. The Holstein-Primakoff transformation. The spin-wave approximation for the ferromagnetic model.
19. The spin-wave approximation for the antiferromagnetic model.
20. The Jordan-Wigner transormation to solve some one-dimensional spin models (I).
21. The Jordan-Wigner transormation to solve some one-dimensional spin models (II).
22. Exact diagonalizations.
23. Abelian (translational) symmetries within exact diagonalizations.
24. The projection and Lanczos methods.