

Many Body Physics (LL XXX, nn: LL=Landau Lifshits; XXX=volume, nn=paragraph)

2024-2025

1. 26/9/2024 Identical particles. Fermions and bosons. Slater determinants. (LL III, 61)
2. 26/9/2024 The Fock space. Matrix elements of one-particle and two-particle operators in the case of the Bose statistics. (LL III, 64)
3. 27/9/2024 Second quantization for bosons. Annihilation and creation operators. Commutation rules. Expression of one-particle and two-particle operators in second quantization. (LL III, 64)
4. 27/9/2024 The field operator for bosons. Commutation rules. (LL III, 64)
5. 1/10/2024 Second quantization for fermions. Annihilation and creation operators. Anticommutation rules. The field operator for fermions. Anticommutation rules. (LL III, 65)
6. 1/10/2024 Introduction to the theory of Fermi liquids. Quasiparticles.

Distribution of the quasiparticles in momentum space. Energy as a functional of the distribution. (LL IX, 1)

7. 3/10/2024 Entropy of a Fermi liquid. Chemical potential. Conditions for the definition of quasiparticles. Effective mass. Entropy and heat capacity of the Fermi liquid. (LL IX, 1)

8. 3/10/2024 Interaction among the quasiparticles. Interaction function. (LL IX, 2)

9. 4/10/2024 Direct and exchange contributions. Density of states at the Fermi energy. (LL IX, 2)

10. 4/10/2024 Galilean invariance. Flux of quasiparticles. Relation between the mass of a particle and the effective mass of a quasiparticle. (LL IX, 2)

11. 8/10/2024 Compressibility of the Fermi liquid. Conditions for the stability of a Fermi liquid (without demonstration). (LL IX, 2)

12. 8/10/2024 Sound propagation in a Fermi liquid. Spin susceptibility of a Fermi liquid. (LL IX, 3)

13. 10/10/2024 Kinetic equation for a Fermi liquid: conditions for the validity of the semiclassical approach.

Linearization of the kinetic equation for small disturbances. (LL IX, 4)

14. 10/10/2024 Kinetic equation in the collision-less regime. Zero sound.

Solution of the kinetic equation for a constant interaction function. Properties and stability of the zero sound solution. (LL IX, 4)

15. 11/10/2024 Introduction to the Green's functions at $T=0$. Heisenberg and Schroedinger representation of the field operator. Equation of motion for the field operator in the Heisenberg representation. (LL IX, 7)

16. 11/10/2024 Expression of the Hamiltonian and of the Particle number operators in the Heisenberg representation. Definition of the Green's function at $T=0$ in the case of fermions. Properties of the Green's function of a homogeneous system. Density matrix. (LL IX, 7)

17. 15/10/2024 Distribution of the momentum of the particles. Fourier

transform of the Green's function. (LL IX, 7)

18. 15/10/2024 Determination of the energy spectrum. The Lehman representation for the Fourier transform of the Green's function. Quasiparticle energies as isolated poles of the Green's function. (LL IX, 8)

19. 17/10/2024 Properties of the Green's function in the vicinity of an isolated pole. (LL IX, 8). Green's function of the Fermi gas. (LL IX, 9)

20. 17/10/2024 Momentum distribution for the Fermi gas. Discontinuity of the momentum distribution for the Fermi liquid at the Fermi surface. (LL IX, 10)

21. 18/10/2024 Thermodynamic properties of the Fermi liquid. The interaction representation. Time evolutions of the operators. (LL IX, 11-12)

22. 18/10/2024 Time evolution of the states. The S matrix. Expression of the Green's function in terms of the S matrix. (LL IX, 12)

23. 22/10/2024 Statement of Wick's theorem. (LL IX, 12) Perturbative

expansion. Feynman diagrams in real space. (LL IX, 13)

24. 22/10/2024 Rules for the Feynman diagrams. Feynman diagrams in momentum space. (LL IX, 13)

25. 24/10/2024 Construction of the Green's function of the Fermi gas, from the time evolution of the field operators. (LL IX, 9)

26. 24/10/2024 Demonstration of Wick's theorem. (LL IX, 13) Self energy. (LL IX, 14)

27. 25/10/2024 Relation between the self energy and the Green's function. (LL IX, 14)

28. 25/10/2024 Expression of the quasiparticle residue Z , of the effective mass, and of the quasiparticle lifetime in terms of the self energy. (LL IX, 14)

29. 29/10/2024 Two-component Green's function. Vertex function. (LL IX, 15)

30. 29/10/2024 Connection between the self energy and the vertex function. Dyson equation. (LL IX, 15)

31. 31/10/2024 Vertex function for small

momentum transfer. The origin of the singular behavior. (LL IX, 17)

32. 31/10/2024 Integral equation for the vertex function. Limits of the vertex function for frequency larger and smaller than the momentum (dynamic and static limit). (LL IX, 17)

33. 5/11/2024 Poles of the vertex function. Zero sound. Identification of Landau interaction function with the dynamic limit of the vertex function. (LL IX, 18)

34. 5/11/2023

35. 7/11/2024 Green's function at finite temperature. Retarded Green's function and its analytical properties. (LL IX, 36)

36. 7/11/2024 Advanced Green's function and its analytical properties. The Green's function at finite temperature. (LL IX, 36)

37. 12/11/2024 Thermal (Matsubara) Green's function. Matsubara frequencies. Connection of Matsubara Green's function with the retarded and advanced Green's function. (LL IX, 37)

38. 12/11/2024 Interaction representation within the Matsubara formalism. Matsubara sigma matrix and its properties.

Expression for the Matsubara Green's function as a statistical average with the non-interacting statistical weight.
(LL IX, 38)

39. 14/11/2024 Rules for diagrams in the Matsubara formalism. (LL IX, 38)

Screening within the random phase approximation.

40. 14/11/2024 Introduction to linear response theory: the classical harmonic oscillator.