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

2023-2024

1. 26/9/2023 Identical particles. Fermions and bosons. Slater determinants. (LL III, 61)
2. 26/9/2023 The Fock space. Matrix elements of one-particle and two-particle operators in the case of the Bose statistics. (LL III, 64)

3. 28/9/2023 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. 28/9/2023 The field operator for bosons. Commutation rules. (LL III, 64)

5. 29/9/2023 Second quantization for fermions. Annihilation and creation operators. Anticommutation rules. Expression of one-particle and two-particle operators in second quantization. (LL III, 65)
6. 29/9/2023 The field operator for

fermions. Anticommutation rules. Introduction to the theory of Fermi liquids. Quasiparticles. (LL III, 65)

7. 3/10/2023 Distribution n of the quasiparticles in momentum space. Energy as a functional of n. (LL IX, 1)
8. 3/10/2023 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)

9. 5/10/2023 Interaction among the quasiparticles. Interaction function. (LL IX, 2)
10. 5/10/2023 Direct and exchange contributions. Density of states at the Fermi energy. (LL IX, 2)

11. 6/10/2023 Galilean invariance. Flux of quasiparticles. Relation between the mass of a particle and the effective mass of a quasiparticle. (LL IX, 2)
12. 6/10/2023 Compressibility of the Fermi liquid. Conditions for the stability of a Fermi liquid (without demonstration). (LL IX, 2)

13. 10/10/2023 Sound propagation in a Fermi liquid. Spin susceptibility of a Fermi liquid. (LL IX, 3)
14. 10/10/2023 Kinetic equation for a Fermi liquid: conditions for the validity of the semiclassical approach. (LL IX, 4)

15. 12/10/2023 Linearization of the kinetic equation for small disturbances. (LL IX, 4)
16. 12/10/2023 Kinetic equation in the collision less regime. Zero sound. (LL IX, 4)

17. 13/10/2023 Solution of the kinetic equation for a constant interaction function. Properties and stability of the zero sound solution. (LL IX, 4)
18. 13/10/2023 Introduction to the Green's functions at T=0. Heisenberg and Schroedinger representation of the field operator. (LL IX, 7)

19. 17/10/2023 Equation of motion for the field operator in the Heisenberg representation. Expression of the Hamiltonian and of the Particle number operators in the Heisenberg representation. (LL IX, 7)

20. 17/10/2023 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)

21. 19/10/2023 Distribution of the momentum of the particles. Fourier transform of the Green.s function. (LL IX, 7)
22. 19/10/2023 Determination of the energy spectrum. The Lehman representation for the Fourier transform of the Green's function. (LL IX, 8)

23. 24/10/2023 Quasiparticle energies as isolated poles of the Green's function. Properties of the Green's function in the vicinity of an isolated pole. (LL IX, 8)
24. 24/10/2023 Green's function of the Fermi gas. (LL IX, 9)

25. 26/10/2023 Momentum distribution for the Fermi gas. Discontinuity of the momentum distribution for the Fermi liquid at the Fermi surface. (LL IX, 10)
26. 26/10/2023 Thermodynamic quantities of the Fermi liquid. The interaction representation. Time evolutions of the

operators. (LL IX, 11-12)

27. 27/10/2023 Time evolution of the states. The S matrix. (LL IX, 12)
28. 27/10/2023 Expression of the Green's function in terms of the S matrix. Statement of Wick's theorem. (LL IX, 12)

29. 31/10/2023 Perturbative expansion. Feynman diagrams in real space. (LL IX, 13)
30. 31/10/2023 Rules for the Feynman diagrams. Feynman diagrams in momentum space. (LL IX, 13)

31. 2/11/2023 Construction of the Green's function of the Fermi gas, from the time evolution of the field operators. (LL IX, 9)
32. 2/11/2023 Demonstration of Wick's theorem. (LL IX, 13)

33. 3/11/2023 Self energy. (LL IX, 14)
34. 3/11/2023 Expression of the quasiparticle residue Z, of the effective mass. and of the quasiparticle lifetime in terms of the self energy. (LL IX, 14)

35. 7/11/2023 Two-component Green's function. (LL IX, 15)
36. 7/11/2023 Vertex function. (LL IX, 15)

37. 9/11/2023 Connection between the self energy and the vertex function. Dyson equation. (LL IX, 15)
38. 9/11/2023 Vertex function for small momentum transfer. The origin of the singular behavior. (LL IX, 17)

39. 14/11/2023 Integral equation for the vertex function. (LL IX, 17)
40. 14/11/2023 Limits of the vertex function for frequency larger and smaller than the momentum (dynamic and static limit). (LL IX, 17)

41. 14/11/2023 Poles of the vertex function. Zero sound. Identification of Landau interaction function with the dynamic limit of the vertex function. (LL IX, 18)
42. 14/11/2023 Green's function at finite temperature. Retarded Green's function and its analytical properties. (LL IX, 36)

43. 16/11/2023 Advanced Green's function and its analytical properties. (LL IX, 36)
44. 16/11/2023 The Green's function at finite temperature. (LL IX, 36)

45. 21/11/2023 Thermal (Matsubara) Green's function. Matsubara frequencies. (LL IX, 37)
46. 21/11/2023 Connection of Matsubara Green's function with the retarded and advanced Green's function. (LL IX, 37)

47. 23/11/2023 Interaction representation within the Matsubara formalism. Matsubara sigma matrix and its properties. (LL IX, 38)
48. 23/11/2023 Expression for the Matsubara Green's function as a statistical average with the non-interacting statistical weight. (LL IX, 38)

49. 28/11/2023 Rules for diagrams in the Matsubara formalism. (LL IX, 38)
50. 28/11/2023 Screening within the random phase approximation.

51. 30/11/2023 Linear response theory.

The response function and its properties. (LL V, 123)
52. 30/11/2023 Kramers-Kronig relations. (LL V, 123)

53. 5/12/2023 Spectral decomposition of the fluctuations. (LL V, 122)
54. 5/12/2023 Fluctuation-dissipation theorem. (LL V, 124)

55. 7/12/2023 Operatorial expression for the response function. (LL V, 126)
56. 7/12/2023 High-frequency limit of the response function and sum rule. (LL V, 126)

57. 12/12/2023 Matsubara susceptibility and its relation with the response function. (LL X, 91)
58. 12/12/2023 Lindhard function in the Matsubara representation and its analytical continuation. High frequency limit: the plasma collective mode of a charged Fermi liquid.

59. 14/12/2023 Coupling of a particle to the electromagnetic field in the classical theory. Lorentz force.
60. 14/12/2023 Gauge invariance. Current.

Continuity equation.

61. 19/12/2023 Coupling of a particle to the electromagnetic field in the quantum theory.
62. 19/12/2023 Current in the quantum theory. Current in the many-body theory. Linear response to the electromagnetic field.

63. 21/12/2023 Scattering of an electron on impurities. Self-energy for disorder-mediated impurity scattering.
64. 21/12/2023 Electromagnetic response of a metal in the presence of impurities. The Kubo approach to the Drude formula for the electrical conductivity.