

Plasma I

Winter semester 2024

List of questions for the oral exam

- 1) Plasma production by ionization and equilibrium with recombination.
- 2) Definition of plasma. Quasi-neutrality. Main differences between plasmas and ideal gases. The plasma parameter.
- 3) Collective effects in plasmas: Debye screening, plasma oscillations.
- 4) Coulomb collisions. Main physical hypotheses and procedure for deriving effective collision frequencies.
- 5) Integration over impact parameters and meaning of the Coulomb logarithm.
- 6) Relaxation processes for exchanges of energy and momentum. Characteristic time scales for electrons and ions
- 7) Plasma resistivity. Ohm's law and 'runaway' electrons.
- 8) Diffusion and mobility from the equation of motion.
- 9) Ambipolar diffusion without magnetic field.
- 10) Particle diffusion parallel and perpendicular to $\underline{B}$.
- 11) MHD waves: Physical meaning and traces of the calculation of the dispersion relation of the shear Alfvén wave.
- 12) Two-fluid model and derivation of the dispersion relation.
- 13) Waves in a fluid magnetized plasma (two-fluid model), in parallel propagation: main principles and discussion of an example of a particular wave (you can choose).
- 14) Waves in a fluid magnetized plasma (two-fluid model), in perpendicular propagation: main principles and discussion of an example of a particular wave (you can choose).
- 15) Cut-off points and resonances: physical meaning and example(s).
- 16) How do we get to Vlasov equation?
- 17) Discussion of conservation laws and of reversibility of Vlasov-Maxwell system.
- 18) How to find fluid equations from Vlasov equation?
- 19) The Vlasov-Poisson model for electrostatic waves in un-magnetized plasmas.
- 20) The two-stream instability.
- 21) Treatment of electrostatic waves using the Landau approach, based on Laplace transform. Main principles of calculation.
- 22) Solution of the problem of the singularity associated with the wave-particle resonance. Principles behind Landau's rules for the evaluation of the integrals in the presence of the singularity.
- 23) Landau damping: general principles, derivation of the formula in terms of the dielectric tensor and physical interpretation.
- 24) Landau damping of a Langmuir wave. Traces of the calculation and discussion of the result.
- 25) Stability of distribution functions with a single maximum. Traces of the proof and discussion of the physical meaning.
- 26) Kinetic description of plasma waves in the presence of a magnetic field $\underline{B}_0$.
- 27) CMA diagram and general considerations on plasma waves in tokamaks.
- 28) The nonlinear ion acoustic wave equation.
- 29) Solution of the soliton equation.

During the discussion of all the above subjects, it might happen that clarifications are asked concerning basic introductory physics subjects of relevance to plasma physics (e.g., Newton's equations, Maxwell's equations, difference between fluid and kinetic models).