**Plasma Physics (nevf122)** winter semester 2023/24 – lecture content

Students are expected to learn everything presented in the lectures, especially the following points:

*1. Basic concepts and types of plasma*

Description of plasma - definition, collective behavior, quantities describing plasma (Debye shielding length, collisional frequency, plasma frequency, plasma parameter)

Debye shielding length + plasma parameter - derivation, physical meaning

Basic types of plasma - thermal and non-thermal plasma, strongly/weakly coupled plasma, collisions, magnetized plasma, discharge and afterglow

examples of plasmas (tokamak, glow discharge, interstellar medium) and corresponding parameters

Saha equation – approximate derivation, explain, ionization equilibrium

*2. Collision processes in plasma*

Types of collisions - elastic, inelastic, reactive and their description.

Collision cross-sections (hard sphere model, interaction potentials (e.g. Lenard-Jones), differential cross section), reaction rate coefficients (typical values for different processes, relation to cross section), collisional frequency and their experimental determination (ion traps, SIFT, stationary and flowing afterglow plasma, ion storage ring). Order of reaction, potential energy surface/curve. Reaction equilibrium, equilibrium constant, activation energy of reaction. Temperature dependence of reaction rate coefficients (Langevin, Arrhenius)

Langevin description of collisions of ions and molecules - premises and derivation.

*3. Elementary processes*

Excitation, Ionization, Description of near-threshold ionization, Penning ionization. Role of negative ions in plasma (electronegative plasma, opacity). Recombination – radiative, dielectronic, dissociative: direct, indirect, tunneling, ternary. Properties of chemical kinetic equation systems in plasma.

*4. Basic discharges in gases*

Avalanche theory, Townsend discharge, Corona, Townsend mechanism and breakdown – derivation, Paschen curve, Detailed structure of glow discharge, Arc mechanism, Description of current-voltage characteristics of DC discharges. High-frequency discharges.

*5. Plasma diagnostics*

Probe methods

- single probe (including derivation of terms for different bias voltage on probe, conditions for use (e.g. mean free path of charged particles with respect to Debye layer etc.), parameters that could be measured and how, plasma and floating potential, EEDF), probe circuit

- how presence of RF field (RF compensation) or magnetic field or negative ions influence measured VA characteristics of single probe

* Double probe method (only basics)

High-frequency diagnostics

* Basics, plasma frequency, influence of collisions
* Microwave resonator method
* Microwave interferometry and reflectometry

Basics of optical spectroscopy

- Einstein coefficients, Lambert-Beer law, absorption coefficient and absorbance, line shape (natural broadening, pressure broadening, Doppler broadening)

- determination of parameters of plasma by absorption and emission spectroscopy (translational, rotational, vibrational temperature, electron number density)

- absorption and emission spectroscopy, rotational, vibrational and electronic spectra of molecules

- CRDS

Corpuscular diagnostics

* Basics, Time of Flight, Magnetic sector analyzer, Quadrupole mass spectrometer, proton transfer mass spectrometer, FT-ICR, Mathieu (stability) diagram