P 24: Codes and Modeling II

Time: Thursday 16:30–17:45 Location: ELP 6: HS 4

Invited Talk P 24.1 Thu 16:30 ELP 6: HS 4

Electron surface scattering kernel for plasma simulations —
•Franz Xaver Bronold and Felix Willert — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

Applying the invariant embedding principle, originally developed for the calculation of the albedo of planetary and stellar atmospheres, to secondary electron emission from surfaces, we construct an electron surface scattering kernel to be used in the boundary condition for the electron Boltzmann equation of a simulation of a plasma confined by a solid. In principle, the kernel takes the microphysics responsible for electron emission and backscattering from the plasma-solid interface fully into account. To demonstrate the potential of the approach, we apply it to a polycrystalline silicon surface using a semiempirical jellium-randium model for the solid. It contains the Schottky barrier, impact ionization across the band gap as well as scattering on phonons, defects, and ion cores. The emission yields we deduce from the kernel, which in turn is obtained by solving the nonlinear embedding equation for the electron backscattering function without approximate decoupling of the angle and energy variables, agree well enough with measured data to support using the kernel in the boundary condition of the electron Boltzmann equation of a simulation describing a plasma in contact with a polycrystalline silicon surface. [1] F. X. Bronold and F. Willert, arXiv:2309.00534.

P 24.2 Thu 17:00 ELP 6: HS 4

Unveiling the non-linear Zeeman effect in isotopes of krypton and xenon at the linear plasma device PSI-2 —
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Isotopic broadening alters the line shape of atomic transitions and contributes noticeably to the laser absorption spectra of neutral Kr and Xe investigated at the linear plasma device PSI-2. Of high interest are the odd-numbered isotopes having a nonzero nuclear spin resulting in the hyperfine interaction. The main challenge in analyzing such isotopes is that the hyperfine and Zeeman terms can be of the same order of magnitudes, rendering conventional weak field and strong approximation formulas inadequate for analysis.

The magnetic field at PSI-2 of < 90 mT creates such conditions for the Kr I 760.4 nm, Kr I 785.7 nm, and Xe I 764.4 nm lines. This contribution shows how to correctly account for the Zeeman effect by using a Hamiltonian containing both hyperfine and Zeeman interaction terms as the perturber. Standard atomic physics procedures allow us to derive the energy eigenvalues and relative intensities. Crucially, the theoretical analysis is backed by experimental data, confirming the validity of the methodology in modeling observed spectral features.

P 24.3 Thu 17:15 ELP 6: HS 4

Modelling study of the effects of gas temperature on self-pulsing spark discharges in atmospheric-pressure argon —
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Self-pulsing discharges, such as transient sparks, are commonly used to generate non-thermal atmospheric pressure plasmas. Although the self-pulsing prevents excessive gas heating and thermalisation of the discharge, gas might still heat to some extent. The increase in gas temperature could alter the discharge stability and the characteristics of the plasma, such as mode transitions and the excitation of ion acoustic waves. In the present contribution, the self-pulsing discharges in argon at atmospheric pressure are analysed by means of a fluid-Poisson model coupled with a circuit equation. The effects of gas heating on the discharges and self-pulsing modes are investigated by treating the gas temperature as a parameter in the model and by coupling a heat equation for the background gas to the fluid-Poisson model. The modelling results show that higher gas temperatures affect both the frequency and the periodicity of the discharges, noting that the change in gas density has the most significant influence, while temperature-dependent collisional processes play a minor role.

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P 24.4 Thu 17:30 ELP 6: HS 4

The Poisson-Boltzmann equation and quasi-neutrality assumption in the presence of electron number perturbations
— •Kevin Köhn[1], Lukas Vogelhuber[1], Dennis Krüger[1], Denis Eremin[1], Liang Xu[2], and Ralf Peter Brinkmann[1] — [1]Ruhr University Bochum, Germany — [2]Soochow University, China

The Poisson-Boltzmann (PB) equation is a 3D elliptical partial differential equation used to determine the electric potential in a plasma chamber with appropriate boundary conditions. Solutions of the PB equation usually exhibit a typical bulk-sheath structure, with strong gradients in the sheath and approximately constant potential in the quasi-neutral bulk. In recent years, much research in the field of partially magnetized discharges, e.g. high power impulse magnetron sputtering, was dedicated to the so-called spoke phenomenon. These spokes can be characterized as self-emerging rotating structures of increased ionization, density and potential that rotate in the ExB direction. As these structures clearly break the discharge symmetry, researchers suggested that in order to fully capture the plasma potential dynamics of such a discharge the quasi-neutrality assumption in the bulk must be dropped and the full 3D PB equation would be required. In this talk, we present investigations of the PB equation in simple geometry with small and large scale periodic electron number perturbations to find a criterion if the quasi-neutrality assumption holds based on pertubation scale, bulk length and Debye length.