Publ. Astron. Obs. Belgrade No. 103 (2024), 39 *Poster*
https://doi.org/10.69646/aob103p039

ELECTRON TRANSPORT IN RADIO-FREQUENCY ELECTRIC AND MAGNETIC FIELDS IN ULTRA-LOW GWP GASES

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Abstract. In this work, we study the transport of electrons in radio-frequency (RF) electric and magnetic fields in ultra-low global warming potential (GWP) gases. Calculations have been performed for electron swarms in $C_3H_2F_4$ and C_3HF_5 using a time-dependent multi-term technique to solve the Boltzmann equation and Monte Carlo simulation.

The progress and further improvements of plasma science require the most accurate modeling of charged particle transport under the influence of electric and magnetic fields in neutral gases. In this work, we study the transport of electrons in RF electric and magnetic fields in ultra-low GWP gases, including $C_3H_2F_4$ and C_3HF_5. Electron swarm transport properties and distribution functions have been calculated using a unified time-dependent multi term theory to solve the Boltzmann equation and Monte Carlo simulation. The motivational factors for this study include the following: (1) understanding electron kinetics and electron heating mechanisms in inductively coupled plasmas, (2) understanding of the interaction between electromagnetic waves and ambient electrons inside gas-insulated switchgears used in electrical power transmission systems. We systematically investigate the explicit effects associated with the electric and magnetic fields including fields to density ratios, field frequency, field phases and field orientations. We also highlight the explicit modification of electron swarm transport coefficients by non-conservative collisions, including the electron attachment and ionization. We have observed a multitude of kinetic phenomena that are generally inexplicable with the conventional transport theory of electron swarms in direct-current (DC) fields. Phenomena of significant note include the increase of mean energy with increasing magnetic field, time-resolved negative differential conductivity, anomalous anisotropic diffusion, and transient negative diffusivity.

Acknowledgments: This work is supported by the Science Fund of the Republic of Serbia, Grant No. 7749560, Exploring ultra-low global warming potential gases for insulation in high-voltage technology: Experiments and modelling EGWIn.