**PiAI Seminar Series: Physics informed AI in Plasma Science**
**9:30-10:30, 21 February 2022 (CET)**
**17:30-18:30, 21 February 2022 (JST)**
**Web Seminar**

# Physics-informed neural network for elucidating electron swarm transport in weakly ionized plasmas

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Physics-informed neural networks (PINNs) have recently attracted attention as a meshfree method for solving partial differential equations. In this seminar, two applications of the PINNs for elucidating electron swarm transport in weakly ionized plasmas are presented. Firstly, the PINNs are used to calculate the electron velocity distribution function (EVDF) under DC uniform electric and magnetic fields via the Boltzmann equation. The electron energy distribution function (EEDF) and electron transport coefficients are calculated from the EVDF, and then they are demonstrated in comparison with Monte Carlo simulation results. Secondly, the PINNs approach is applied to the measurement of the ionization rate coefficient $k_\mathrm{i}$, bulk electron drift velocity $W_\mathrm{r}$, longitudinal diffusion coefficient $D_\mathrm{L}$, and third-order transport coefficient $D_3$. Those electron transport coefficients are required for describing the continuity of electrons:

$$\frac{\partial n}{\partial t} = k_i N n - W_\mathrm{r}\frac{\partial n}{\partial z} + D_\mathrm{L}\frac{\partial^2 n}{\partial z^2} - D_3\frac{\partial^3 n}{\partial z^3}, \quad (1)$$

where $n = n(t, z)$ is the number density of electrons and $N$ denotes that of gas molecules. The Dirichlet boundary condition is employed by using $n(t, z)$ measured at several drift distances, and Eq.(1) is solved by the PINNs approach. While training the neural network, $k_i$, $W_\mathrm{r}$, $D_\mathrm{L}$, and $D_3$ are optimized to minimize the mean square of the PDE residual. By using this method, the value of $k_\mathrm{i}$ above The determined electron transport coefficient in $N_2$ is presented.