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Discussion on Electron Temperature of Low-Pressure Discharge Oxygen Plasma with Non-Maxwellian EEDF Based on Statistical Physics

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We reconsider electron temperature of non-equilibrium oxygen plasmas based on thermodynamics and statistical physics by the relationship between entropy and mean energy of electron gas. First, we solve the Boltzmann equation to obtain electron energy distribution function (EEDF) $F(\epsilon)$ of the oxygen plasma for a given reduced electric field E/N. We also simultaneously solve kinetic equations to determine some essential excited species in the oxygen plasma, since the EEDF should be self-consistently solved with the densities of collision partners. Next, we calculate the electron mean electron energy $U = \langle\epsilon\rangle = \int_0^\infty \epsilon F(\epsilon)\mathrm{d}\epsilon$ and entropy $S = -k\int_0^\infty F(\epsilon)\ln[F(\epsilon)]\mathrm{d}\epsilon$ for each value of the reduced electric field E/N. Then, we can obtain the electron temperature calculated as $T_\mathrm{e}^\mathrm{th} = [\partial S/\partial U]^{-1}$. After that, we discuss the difference between T_e^th and the kinetic temperature $T_\mathrm{e}^\mathrm{k} \equiv (2/3)\langle\epsilon\rangle$, as well as the temperature given as a slope of the calculated EEDF for each value of E/N from the viewpoint of statistical physics as well as elementary processes.

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