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A transcendental method for calculation of electron transport and rate coefficients in weakly ionized magnetized plasma

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In the presence of a constant electric and magnetic field, the electron energy distribution function varies with the reduced electric field E/N where E denotes the magnitude of the applied electric field and N denotes neutral atmospheric density, the reduced gyrofrequency $\omega_{\rm ce}/N$ (where $\omega_{\rm ce} = q_{\rm e}B/m_{\rm e}$ is the electron cyclotron frequency for an applied magnetic field B), and the angle between $\vec{E}$ and $\vec{B}$, χ. Consequently, rate constants of electron impact processes in addition to electron transport coefficients will vary as a function of $(E/N, \omega_{\rm ce}/N, \chi)$. Here, we provide the theory to solve a transcendental equation for an effective reduced field $E_{\rm eff}/N$ to replace $(E/N, \omega_{\rm ce}/N, \chi)$. Comparison of electron rate and transport coefficients as a function of $(E/N, \omega_{\rm ce}/N, \chi)$ obtained via BOLSIG+ [1] and via the presented method are demonstrated for air, the atmosphere of Jupiter, and CO_2. The new approach may be used in modeling of partially magnetized plasmas encountered in the context of transient luminous events, e.g., sprite streamers in the atmosphere of Jupiter [2, 3], in modeling the propagation of lightning's electromagnetic pulse in Earth's ionosphere [4], and in various applications of nonthermal CO_2 plasma [5].

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