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Transport dynamic equations with impurity in tokamak plasmas

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The transport dynamics of various ions and electron in tokamak plasmas is a very important research area. Herein, on the basis of the non-equilibrium statistical theory, the transport equations of impurity ions, deuterium ion and electron were derived from Fokker-Planck kinetic equation. The transport dynamics of impurity ions with Zth-order charge which is forming in the various ionization levels and the explicitly collisions contribution between different particles are systematically analyzed in this work. The basic equations are re-derived and simplified on the basis of the previous works. Therefore, the transport equations of different particles in this system are concise and systematic.

$$\frac{\partial n}{\partial t}+\nabla\cdot(n\boldsymbol{u})=S^N \tag{1}$$

$$\frac{\partial u_{\parallel}}{\partial t}+\boldsymbol{u}\cdot(\nabla u_{\parallel})+\frac{\hat{\boldsymbol{b}}}{nm}\cdot(\nabla\cdot\vec{\pi})+\frac{\hat{\boldsymbol{b}}}{nm}\cdot[\nabla(nT)] =\frac{Ze}{m}\hat{\boldsymbol{b}}\cdot\boldsymbol{E}+\frac{\hat{\boldsymbol{b}}\cdot\boldsymbol{R}}{mn}+\frac{\hat{\boldsymbol{b}}\cdot\boldsymbol{S}^M}{mn}-\frac{u_{\parallel}}{n}S^N \tag{2}$$

$$\frac{3}{2}n[\frac{\partial T}{\partial t}+\boldsymbol{u}\cdot(\nabla T)]+nT\nabla\cdot\boldsymbol{u}+\nabla\cdot(\vec{\pi}\cdot\boldsymbol{u})+\nabla\cdot\boldsymbol{q} =Q+S^E-\boldsymbol{u}_{\parallel}\cdot\boldsymbol{S}^M+(\frac{1}{2}mu_{\parallel}^{\,2}-\frac{3}{2}T)S^N+\boldsymbol{u}_{\parallel}\cdot(\nabla\cdot\vec{\pi}) \tag{3}$$

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