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粒子密度の連続の式に対するジャイロ運動論的熱ソースの影響

Gyrokinetic Heat Source Effects on the Particle Continuity Equation

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Gyro-center heat sources (and/or sinks) are commonly used to make ion temperature gradient in global Full-F gyokinetic simulations. Since gyrokinetic models are formulated by the phase space transformation from the particle phase space to the gyro-center phase space, gyrokinetic simulations do not follow time evolution of the particle distribution function, but the gyro-center distribution function. Therefore, the particle density can be changed by pure gyro-center heat sources which do not change the gyro-center density. Contribution of a gyro-center source to particle flux ($\mathbf{\Gamma}$) appears in the general push-forward representation of the particle flux by considering a gyrokinetic model with the gyro-center source [1],

$$\mathbf{\Gamma} = \mathbf{\Gamma}_{\rm gy} + \mathbf{\Gamma}_{\rm pol} + \mathbf{\Gamma}_{\rm mag} + \mathbf{\Gamma}_S. \tag{1}$$

$\mathbf{\Gamma}_{\rm gy}$ is the gyro-center flux which is only a part of particle flux and is directly calculated by gyrokinetic/gyrofluid simulations. $\mathbf{\Gamma}_{\rm pol}$ is the polarization flux which has a form of partial time derivative of the polarization vector. $\mathbf{\Gamma}_{\rm mag}$ is the magnetization flux which has a curl form. Finally $\mathbf{\Gamma}_S$ is the particle flux caused by the gyro-center source. Explicit push-forward representations in terms of gyrofluid moments were derived for the standard electrostatic gyrokinetic model without a source term [1, 2]. It is found that Belova's result for the particle flux representation [2] does not change even if the gyro-center source is considered in the standard electrostatic gyrokinetic model. On the other hand, the particle flux due to the gyro-center perpendicular heat source explicitly appears in the alternative representation. In both cases, however, particle sources arising from the gyro-center heat source appear in particle continuity equations. Particles move by the gyro-center perpendicular heat source through the change of their Larmor radii. Hence, the particle sources due to the gyro-center heat source do not change the total number of particles and change the particle density locally. Their effects for ion density are bigger than those for electron density. This nature was used to study transport barriers in tokamak plasmas by gyrokinetic simulations [3].

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