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Impact of the poloidal inhomogeneous particle sources on the tokamak plasma transport

Young-Hoon Lee[1], Hogun Jhang[2], Sung Sik Kim[2], and Jungpyo Lee[1]

[1] Department of Nuclear Engineering, Hanyang University, Republic of Korea
[2] Korea Institute of Fusion Energy, Republic of Korea

The transports of plasma particles, toroidal momentum, and energy in a core tokamak have been analyzed by the 1-D radial transport equations, because the plasma density and temperatures are likely uniform poloidally in a flux surface and the turbulence fluctuation time scale is much smaller than the transport time scale. However, when the non-negligible poloidal inhomogeneous source (e.g. neutral beams, pellet injection) exists, the 2-D (radial, poloidal) transports of the plasma can be important even in the transport time scale. As a first step to develop the 2-D transport model, we investigate the initial plasma response to the poloidal source before the ion neoclassical viscosity plays a role. Due to the source, a strong instability of the radially varying electrostatic potential occurs at the initial phase and makes ExB poloidal flow, as called "Stringer spin-up (SSU)".

While the spin-up was investigated by Hassam using a reduced MHD model [A. B. Hassam, J. F. Drake, Phys. Fluids B 5 (1993) 4022.], we modified a "3+1" gyrofluid model considering the exact time and length scales of particle fuels. To reproduce the Landau damping, Hammet-Perkins closure model [G. W. Hammet and F. W. Perkins Phys. Rev. Lett. 64 (1990) 3019] is included in our gyrofluid model. Compared to the MHD model, the gyrofluid model has unique features describing GAM and Landau damping. We found that there is a threshold of the instability in terms of the poloidal source intensity (see Fig.1) and its physical background is investigated with great details. Interestingly, it is shown that the Landau damping rate determines the type of the instability, either GAM or SSU, and affects to the threshold source intensity. Through this study, parametric equation of the threshold source intensity and certain Landau damping rate which determines the instability type is derived.

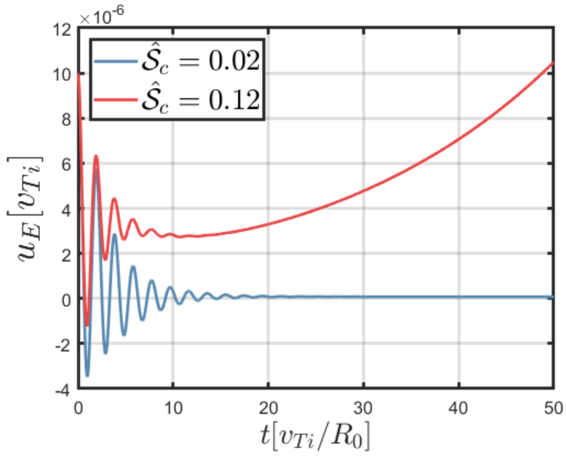

Figure 1. The time behavior of ExB flow in the presence of the poloidal particle source for two different source intensities. Here, $\hat{\boldsymbol{S}}_{\boldsymbol{c}}$ is the particle source intensity normalized to $\boldsymbol{n_0} v_{ti}/qR_0$, where $\boldsymbol{n_0}$ is the equilibrium density, v_{ti} is the ion thermal velocity, q is the safety factor, and R_0 is the major radius.