

Description of Additional Supplementary Files

File Name: Supplementary Movie 1

Description: Comparison between two simulation results of the KSTAR ohmic breakdown scenario with and without considering the self-electric fields. (Upper) Averaged log-scale electron density. (Lower) Log-scale electron density in the RZ plane without (Left) and with (Right) considering the self-electric fields. The magenta arrows indicate the directions and relative magnitudes of the total electron flow velocities.

File Name: Supplementary Movie 2

Description: Fluctuating nature of the ohmic breakdown plasma. 2D snapshots of the ohmic breakdown plasma: (1) linear-scale electron density, (2) charge-density, (3) vorticity, (4) parallel component of the total electric field, and (5) its temporal average.

File Name: Supplementary Movie 3

Description: (Left) Color contour is the charge density and green arrows indicate the directions and magnitudes of total electron flow velocities that are sum of the parallel electron flows and $E \times B$ flows. (Right) Color contour is the electron density and magenta z-surfaces are the electron losses at the wall.

File Name: Supplementary Movie 4

Description: Detailed simulation results of the KSTAR ohmic breakdown scenario. (Upper Left) Linear-scale electron density, (Upper Middle) Log-scale electron density, (Upper Right) Log-scale ion density, (Lower Left) Electron temperature, (Lower Middle) Absolute magnitudes of the total parallel electric fields, and (Lower Right) Plasma potential.

File Name: Supplementary Movie 5

Description: Comparison between two simulation results of artificial simple X-point scenarios. Temporal evolutions of log-scale electron densities of (Left) Forward $\mathbf{B}_{RZ}$ case and (Right) Reversed $\mathbf{B}_{RZ}$ case.