Up-down asymmetry induced particle pinch in global edge simulations

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A new particle pinch mechanism other than the Ware effect [1], thermal-diffusion [2] and turbulence equipartition theory [3] has been observed in our global tokamak edge simulations with GDB code [4] – a 3D drift-reduced Braginskii based electromagnetic turbulence model. In this study, radial simulation domain spans from the closed flux region to the SOL ($0.8<r/a<1.1$ in normalized units) and the simulation is initialized with monotonically decreasing temperature profiles and flat density profile. A flux-driven heat source S_T is located on the core side ($r/a<0.84$) in order to maintain a target $T_{e,i}$ at the boundary. Meanwhile, a Gaussian shape particle source S_n with 1 cm width is located near the LCFS ($0.96<r/a<1.05$). Figure 1 shows time evolution of the flux surface averaged radial density profile for this 12 ms run. Immediately after the SOL particle source is turned on at $t\simeq0.2$ ms, a strong inward (up-gradient) particle flux in the closed flux region away from the particle sourcing zone appears. At $t\simeq4$ ms, density profile inside the LCFS flattens and at $t\simeq8$ ms a central-peaked quasi-steady density profile is reached. Analysis shows that the net inward particle flux $\Gamma_{n,r}$ is due to the inboard-outboard asymmetric radial component of $E\times B$ drift, or, the up-down asymmetric electrostatic potential ϕ since $v_{E,r}\propto\partial\phi/\partial\theta$. As discussed in [5], up-down asymmetric ϕ is mainly originated from the compressibility (or, curvature) contribution of the ion transverse heat flux as predicted by neoclassical theory. Once the transverse heat flux term is turned off (e.g., no up-down asymmetry driver) at $t>8.5$ ms, radial density profile starts to relax and are no longer central-peaked.

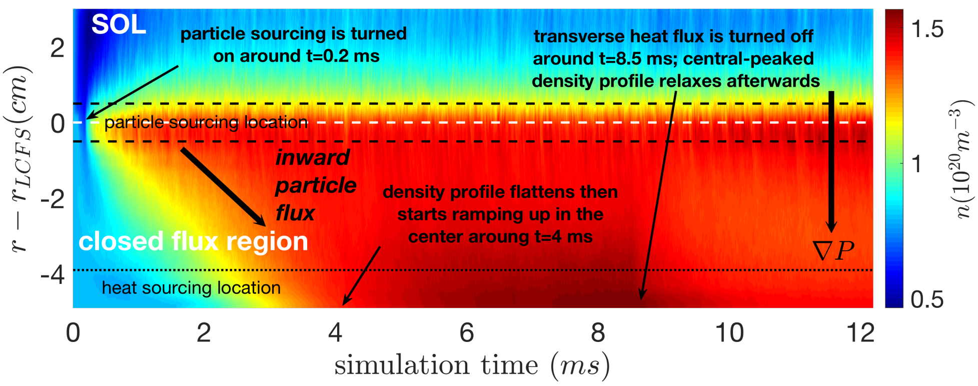

Figure 1: Time evolution of radial density profile. White dashed line designates separatrix, black dashed lines represent particle source zone, dotted line indicates heat source zone.

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