The Influence of Blobs on Neutrals in the Scrape-Off Layer

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Why Study Dynamical Neutral Interactions with Plasma?

Neutrals in magnetically confined plasmas can originate from plasma-wall interactions or be puffed into the chamber for fueling or imaging purposes. Neutrals from gas-puffing are at room temperature and their mean-free path for ionization is short compared to the width of the Scrape-Off Layer (SOL), but similar to the perpendicular length scale of blobs.

A coupled neutral-plasma model would allow for understanding the influence of SOL plasma filaments on the neutral particles, but also for obtaining realistic plasma density source profiles. The latter can also be used to assess plasma fueling efficiencies for various configurations.

The results presented here are to be published in [1].

1D Simulations

The plasma is simulated as a static profile with an outwards propagating perturbation to density and temperature. This allows for dynamically obtaining the neutral responses to plasma fluctuations.

It is observed that cold neutrals are ionized in the SOL, whereas warm and hot neutrals are mostly ionized in edge. Also, blobs induce a short interval of increased fueling, followed by a period of decreased fueling as steady state rebuilds.

Cold, Warm and Hot Neutrals

The neutrals are described by a 3-species fluid model which includes cold neutrals ($T_{\text{cold}} \approx 25 \text{ meV}$), warm neutrals ($T_{\text{warm}} \approx 10 \text{ eV}$) and hot neutrals ($T_{\text{hot}} \approx 30 \text{ eV}$). All neutral densities evolve according to diffusion

$$\partial_t n_\sigma - \nabla \cdot (D_\sigma \nabla n_\sigma) = S_\sigma,$$

where

$$D_\sigma = \frac{T_\sigma}{k_{\text{eff}} m_\sigma n_\sigma}.$$

The neutral sinks in $S_\sigma$ are due to ionization, whereas charge exchange collisions introduce both source and sink terms.

The mean-free paths for cold neutral atoms for ionization and charge exchange is much smaller than those for warm and hot neutrals. This suggests that the density flux of warm and hot neutrals across the LCFS exceeds that of cold neutrals.

Conclusions

• The neutral inward flux at LCFS from warm and hot neutrals is dominating over that of cold neutrals. I.e. the results suggest that gas puff fueling in tokamaks relies on the charge exchanged hot neutrals.

• Results of the 1D model were compared to those of both a similar simplified 2D model and those obtained from HESEL simulations. We observe that results from 1D simulations are reflected in 2D simulations.

• Improved coupling between a neutral diffusion model and the HESEL code is the basis of our current work.

References