SELF-SUSTAINED DIVERTOR OSCILLATION DRIVEN BY MAGNETIC ISLAND DYNAMICS IN TORUS PLASMA

The divertor is used to protect the core plasma from being contaminated and helps in the removal of the particles. But this may put an excessive heat load on the divertor itself. Plasma detachment is the state where the pressure gradients are parallel to the magnetic field and, consequently, low ion flux and power to the material bounding the reactor. The detachment plasma is produced by applying an external magnetic field perturbation with supplementary magnetic coils. This creates the magnetic island, a magnetic field structure which enhances the peripheral radiation energy losses and pushes plasma to the detachment state. It was observed that the magnetic island and the transition point of the plasma between attachment and detachment states underwent self-sustained oscillations. The parameters of the plasma current at the divertor influence the magnetic island width, which in turn changes the plasma parameters. The competitive relationship between the bootstrap (self-generated plasma current) current and the magnetic island is described by a predator-prey model. This model successfully reproduced the experimental results.

EQUATIONS

The predator-prey model is defined using two evolution equations for the magnetic island width and bootstrap current. It uses the modified Rutherford equation and a heuristic model, respectively.

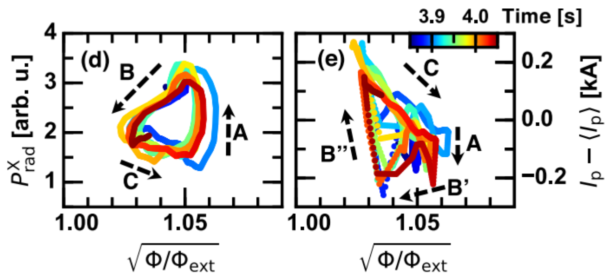
$$\frac{\partial W}{\partial t} = V_M \frac{\delta^2}{W^2} - V_M + C\frac{j_{\mathrm{BS}}}{W},$$

$$\frac{\partial j_{\mathrm{BS}}}{\partial t} = \alpha j_{\mathrm{BS}} - \beta W j_{\mathrm{BS}},$$

W is the width of the magnetic island and δ is the width of the vacuum magnetic island, V_M is the magnetic diffusion speed, and C is the coupling coefficient.

j is the bootstrap current, α linear growth rate, and β is the nonlinear saturation coefficient. The net rate of increase of the bootstrap current is the rate at which it grows minus the rate at which it saturates. (Saturation depends on the magnetic island width, which gives the W term for β **?**) Solving these equations simultaneously gives us the self-reinforcing predator-prey model.

PLOTS



In the first plot, the detachment transition occurs when the W reaches a critical value and X Point radiation intensity increases (A); during the detachment phase, W reduces, and the radiation decreases (B); when the detachment is complete, the electron temperature is regained and the width increases (C).

In the second plot, plasma current increases steeply when W reaches a minimum during attachment (B”), it then decreases when W increases (C), the trajectory remains stable during the X-Point radiation rise (A), and the current remains steady when W decreases (B’)

SOFTWARE

It uses MyView2, software built on python libraries, to visualise LHD data.

QUESTIONS

1. **Why does the electron temperature drop due to impurity accumulation at the X-Point? What is the significance of X-Point and O-Point?**
2. **How does the divertor heat flux reduce when impurity radiation increases? What exactly is the impurity here?**