Motivation

- Divertors isolate the confinement core from regions where the plasma and structural surfaces interact.
- Divertors in stellarators can make use of magnetic island structures at the edge of the confinement region; these structures are device-dependent.
- In long pulse stellarator experiments, edge island divertors can be used as a method of plasma particle and heat exhaust, e.g., W7-X.
- 3D divertors generated by an edge magnetic island structure have substantially different physics properties from 2D poloidal divertors; Knowledge of the detailed power flow and loading on 3D divertors and its relationship to the long connection length scrape off layer physics is a newCompact Toroidal Hybrid (CTH) research thrust, and a component of the US collaborative effort with W7-X.

Overview

- We report the results of initial calculations using the EM3C-EIRENE code,[2,3] using three potential divertor plate locations relative to the island structure.
- CTH will be operated as a pure stellarator with no plasma current. Plasma generation and heating will be accomplished with a 200kA, 38 GHz gyrotron system under construction; operation will be at 24 harmonic. The CTH vacuum rotational transform can be varied from \( q_0 = 0.02 \) to 0.35 by adjusting the ratio of currents in the helical and toroidal field coils.
- The shaping vertical field (SVF), poloidal coil set is used to adjust the shear of the rotational transform profile, and hence the size of edge islands.
- The magnitude and phase of islands can be adjusted with a set of five error correction coils (ECC) that produce an \( m=1 \) perturbation.

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References
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CTH has a flexible coil set that allows for exploration of multiple magnetic field configurations

- With magnetic island width and phase control, we explore three divertor-like structures using the EM3C-EIRENE code.

- Symmetry breaking islands are generated with error correction coils. Shown below is an example \( m/n = 1/3 \) island near the edge.

The rotational transform profile, \( \beta \), is modified by changing the ratio and direction of currents in the TF and HF coils.

- For these studies EM3C-EIRENE is used to model the temperature distribution at the divertor-like plate.

Power input at core \( = 500 \)kW
Core electron density, \( n_e = 4 \times 10^{19} \) m\(^{-3} \)
Perpendicular particle diffusivity, \( D_\perp = 1.0 \) m\(^2\)/s
Perpendicular thermal diffusivity, \( D_\parallel = 3 \times 10^{-5} \) m\(^2\)/s

Top-port Plate
- Plate could be inserted and retracted with a linear motion feedthrough
- Could be imaged with cameras viewing from lower ports
- Small island size

For these studies EM3C-EIRENE is used to model the temperature distribution at the divertor-like plate.

- Plate could be inserted and retracted with a linear motion feedthrough
- Not easily viewable with cameras
- Larger island width compared to inboard and top plates

1 Inboard Plate

- While moving this plate is possible, connecting actuators and signal lines is difficult compared to other locations.
- Viewable with infra-red cameras located at side ports
- Moderate island size

Plate Temperatures
- The plate is positioned at three major radial positions
- Hotter are the temperature contours at the plate
- As the plate is moved toward the core, more power is deposited on the plate

- Similar temperature and power deposition patterns on outboard plates near \( x \) and \( o \)-points suggest that the deposition is dominated by the background magnetic field configuration.

Surface of section plots superimposed with temperature contours at five toroidal locations on the front face of the outboard plate.

- Diffusivity scan with \( y = D_\parallel \) shows slightly broadened and lower temperature distribution as \( D_\parallel \) increases.
- Note the different temperature scales. All plots are at \( t = 0.04 \)s.

- Energy deposition is highest on the ‘C’ panel where the island \( o \)-point fully intersects the inboard plate.

Energy deposition

- The inboard plate/magnetic island intersection is not symmetric at the ‘A’ and ‘C’ plates.

Diffusivity (D\_parallel) Scan Results

- Overall temperature decreases as \( D_\parallel \) increases
- Temperature pattern is more localized as \( D_\parallel \) decreases

- Power deposition at four toroidal locations on the front face of the inboard plate.