The Madison Symmetric Torus (MST) is a large tokamak designed to study plasma physics in a non-axisymmetric configuration. NBI can either suppress or enhance core most tearing mode (M1) by controlling the pitch distribution of the fast deuterium ions. The fast ion population can be adjusted by changing the neutral beam injection (NBI) conditions to optimize the mode suppression. NBI on MST shows that with the right NBI conditions, the core most tearing mode can be suppressed.

## Overview of MST

The MST has a major radius of 1.7 m and a minor radius of 0.8 m, providing a large aspect ratio for plasma confinement. The poloidal field strength is 0.2 T, and the toroidal field strength is 8 T, allowing for a wide range of plasma parameters to be explored.

## Simulating MST with Dras

Detailed field evolution and mode structure can be simulated using an MHD model. This model includes:
- Toroidal and poloidal magnetic fields
- Neutral beam injection
- Core-confined fast ions
- Tearing mode development
- Effects of sawteeth

## Introduction to RIO

RIO is a code designed to study plasma physics in large, non-axisymmetric devices like MST. It can handle time-varying fields and evolving mode structures. The key equations used in RIO include:
- Lorentz equation
- Hamiltonian framework
- Generalized coordinates

## Modeling NBI with RIO

Neutral beam deposition is modeled through changes in magnetic field strength. The fast ion density can be reduced by optimizing the pitch distribution of the fast ions. A similar level of fast ion acceleration is observed in both MST and RIO simulations. The fast ions are observed to become more field-aligned as they interact with the stochastic core field.

## Fast Particle Orbits in a Stochastic Field

Fast particle orbits in MST involve a range of core temperatures and stochasticity. The pitch distribution of fast deuterium ions is observed to be well-confined and field-aligned. The fast ion density is reduced at the sawtooth crash, consistent with observations in MST simulations.

## The Effect of Sawteeth on the Fast Ion Distribution

In MST, the sawtooth is observed at high pitch, core-confined fast deuterium ions become less significant than a similarly sized tokamak. The latter allows for both neutral beam injection from sawtooth crashes and stochasticity in the plasma.

## Simulation of 2D islands

Island structures are generated by changes in the magnetic field, leading to stochastic orbits. The model can predict island merging times, allowing for the optimization of NBI conditions.

## Summary and Conclusions

- Modeling the fast ion confinement in MST is challenging due to the large number of overlapping time scales and rapidly changing magnetic fields.
- NBI can either suppress or enhance core most tearing mode (M1) by controlling the pitch distribution of fast ions.
- High energy beam injection can be seen to control the sawtooth crash, leading to improved plasma parameters.

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