Goals of HSX

Demonstrate the potential benefits of quasisymmetry

• Quasisymmetry results in reduced electron thermal diffusivity
• Hollow density profiles with peaked temperature profiles in mirror mode operation are attributed to neoclassical thermodiffusion
• Reduction of thermodiffusion with quasisymmetry results in peaked density profiles with peaked temperature profiles

Invited talk by J. Canik Friday morning

• HSX has begun operations at the full design field of B=1.0 T
• Thermal plasmas with \( T_e = 3 \text{keV} \); Poster by Likin
• New ECH transmission line expands available power; Poster by Radder
• Bootstrap current unwinds transform in QHS; Poster by Schmitt
• Improved density profiles with peaked temperature profiles
• Better mode control results in doubling plasma stored energy
• Quasioptical Transmission Line permits higher power operation

Summary

• We have demonstrated reduced particle transport and electron thermal conductivity in a quasisymmetric stellarator at B=0.5 T
• Has achieved ~2 keV central electron temperature at B=1.0 T with only 100 kW injected power
• Program evolving toward understanding role of reduced neoclassical transport on anomalous transport levels
• We have upgrades coming online in diagnostics and available heating power that will allow us to explore this issue

Operations Upgrades

HSX Now Operating at B=1.0T !

- Electron Temperature
- Plasma Density
- Optical Transmission Line

- New Mirror Configuration for Symmetry Breaking
- Placing optics in a peanut shell improves helical symmetry

- Neoclassical transport and parallel resistive damping increased

<table>
<thead>
<tr>
<th>Mirror</th>
<th>QHS</th>
<th>New Mirror</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma Density</td>
<td>Optical</td>
<td>Plasma Density</td>
</tr>
<tr>
<td>Temperature profiles matched between QHS and Mirror</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirror required 2.0 times injected power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density profiles don't match due to thermodiffusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermodiffusion drives hollow density profiles in Mirror</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

New Mirror Configuration

- Neoclassical transport and parallel resistive damping increased

Key points:

- Quasisymmetry results in reduced electron thermal diffusivity
- Hollow density profiles with peaked temperature profiles in mirror mode operation are attributed to neoclassical thermodiffusion
- Reduction of thermodiffusion with quasisymmetry results in peaked density profiles with peaked temperature profiles

Thermal and Particle Transport

- Electron density is peaked and quite independent of rotation
- Kinetic stored energy (from Thomson scattering) is about 110 J and the central electron temperature appears to be higher than 2 keV (TS limit at the cell)
- Plasma density is peaked and quasi-independent of absorbed power

- Temperature profiles matched between QHS and Mirror
- Density profiles don't match due to thermodiffusion

- Thermodiffusion drives hollow density profiles in Mirror

Open Questions

- Does optimizing for neoclassical transport suppress turbulent transport?
- Is it harder to get an electron root in a quasisymmetric stellarator?
- LHD shows evidence of reduced anomalous transport with inward shift of Poloidally shifted experiments to test working hypotheses in HSX are encouraging but mirror bars are too high
- CERC (Central Electron Root Confinement) observed in CHS, LHD, TJ-1H and W7-X

Quasisymmetry Reduces Neoclassical Thermal and Particle Transport

- 2nd Harmonic ECH at B=0.5 T; QHS lower thermal conductivity

- Optical Transmission Line Permits Higher Power Operation

- New Mirror Configuration for Symmetry Breaking

- Neoclassical transport and parallel resistive damping increased

- Thermodiffusion drives hollow density profiles in Mirror