Recent Results and New Directions of the HSX Program

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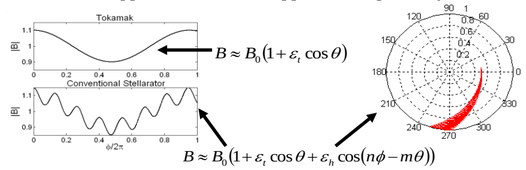
The HSX Device

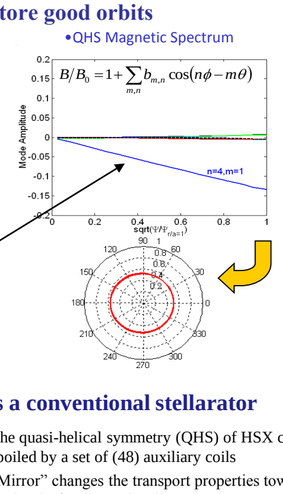
Conventional Stellarators can have "Bad" Trapped Particle Orbits

- A tokamak only has a toroidal modulation in the magnetic field strength
  - Trapped particles make closed orbits -> no net radial drift
- A conventional stellarator also has helical modulation in |B|
  - Particles trapped in the helical ripple do not generally have closed orbits => radial drift



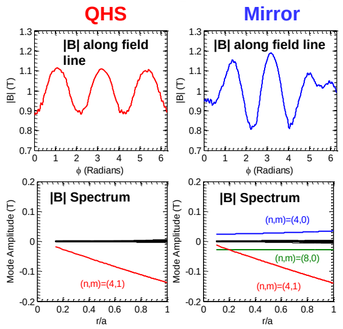
"Quasisymmetry" can restore good orbits

- Drifts off magnetic surfaces are only dependent upon the spectrum of |B| in flux coordinates, not symmetry in the vector components
- Symmetry in |B| insures good confinement
  - -quasi-axisymmetry
  - -**quasi-helical symmetry (HSX)**
  - -quasi-poloidal symmetry
- True symmetry is a subset of quasisymmetry

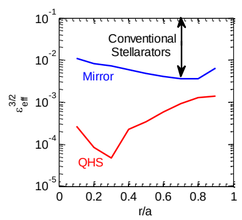


QHS

HSX can operate with QHS or as a conventional stellarator

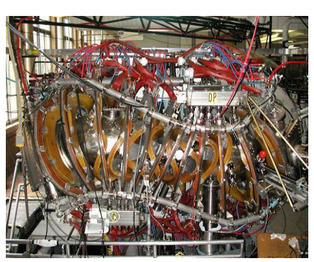


- The quasi-helical symmetry (QHS) of HSX can be spoiled by a set of (48) auxiliary coils
- "Mirror" changes the transport properties towards the level of a classical stellarator
- Effective ripple larger than QHS, still small compared to many conventional stellarators



The HSX Device

Major Radius	1.2 m
Minor Radius	0.12 m
Number of Field Periods	4
Coils per Field Period	12
Rotational Transform ***Effective*** transform (N- mι)	1.05 →1.12 ~ 3
Magnetic Field	1.0T
ECH Power (75 ms)	2 x 100kW 28 GHz



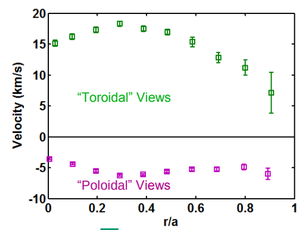
Other Posters at Workshop

- **This session:**
  - **Likin: Power Balance vs Heat Pulse Thermal Conductivity**
  - **Cook: Stability Analysis using SIESTA**
- **Next Session:**
  - **Wilcox: Measurement of Reynolds Stress Flow Drive in HSX**

Plasma Flows

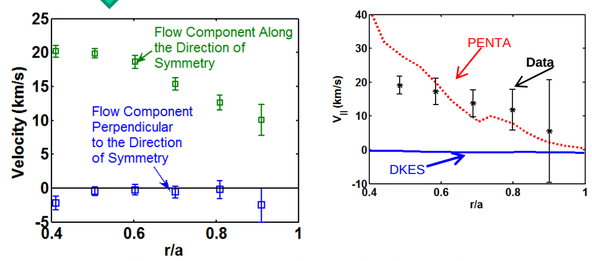
(Talk by Briesemeister Monday)

Measured flows are predominantly in the direction of symmetry



- Intrinsic rotation velocities of up to 20 km/s in the symmetry direction have been measured with the ChERS system and compared to the PENTA code
- Speed increases with increasing ECH power

$V_{||}$ Calculated by PENTA Agrees With the Measured $V_{||}$ For r/a>0.5

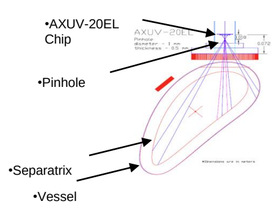


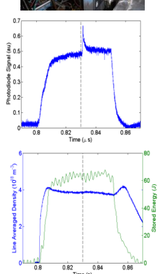
- DKES under-predicts $V_{||}$ by more than an order of magnitude
- Flows predicted by PENTA with momentum conservation show better agreement
- Synthetic diagnostic shows poor E_r resolution and comparison in core due to geometrical factors and large flow speeds relative to thermal velocity

Impurity Transport

- Impurity control and effective helium exhaust are open areas of research for the stellarator reactor concept
- The expected "Ion Root" operating point of a stellarator reactor is predicted to enhance impurity confinement
- Some stellarators have seen unexpected, and unexplained increase in impurity transport under specific operating conditions
- W7-AS had an "High Density H-mode"[Grigull, '01]; LHD has an impurity "hole" [Ida, '09]
- We have undertaken an experimental program to measure the impurity transport properties of the HSX stellarator. Our goals are to:
- Inject aluminum neutrals into HSX plasmas using a laser blow-off technique
- Measure the resulting radiation using AXUV photodiode arrays
- Determine the impurity diffusivity and convective velocity using the STRAHL code
- Compare these findings with the neoclassical model using the PENTA code

- Aluminum has been injected into HSX discharges
- The injection was visible on a photodiode
- The injection did not perturbing the background plasma parameters
- Two photodiode pinhole cameras have been installed on HSX, and five more are under construction.





Diagnostic Improvements

- **ECE system has been upgraded to 16 channels with improved detectors and amplifiers for heat pulse propagation studies**
- **Thomson scattering is now two pulse system and scattered pulses are being digitized for improved measurement accuracy and better signal to noise**
- **The reflectometer has been upgraded to a doppler system to augment flow measurements**
- **Two toroidally separated additional H-alpha arrays have been added to look at profile differences observed with different fueling locations.**
- **Upgrades to the CXRS beam are under investigation for improved E_r measurements**

2 Gyrotrons Now Operational

(See Poster by Likin for Heat Pulse Propagation)

- **Heating power doubled to potentially 200kW into torus (need to connect more capacitor bank sections into power supply)**
- **2nd source steerable and can be modulated – first results Likin Poster**
- **Profile differences observed dependent on heating vs fueling locations**

Equilibrium Reconstruction with V3FIT

(Talk by Schmitt (Anderson) Thursday)

Targeted Optimization of Stellarators

18th Int'l Stellarator/Heliotron Workshop, 29 Jan. – 3 Feb. 2012, Canberra – Murramarang Reserve, Australia