Outstanding Issues in Transport Physics for DEMO

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Transport Issues in DEMO

- DEMO will need higher P_{fusion}, higher Q, higher operational reliability compared to ITER

- Simultaneous achievement and sustainment of

Improved Confinement and Macroscopic Stability
in reactor-like conditions ($T_e = T_i$, high density, low external torque, alpha heating,…) are required.

This presentation focuses on

1. ITBs with Reversed Magnetic Shear

2. H-mode and Rotation

Reducing Transport in DEMO

• The following stabilization mechanisms are likely to be ineffective in DEMO:

NBI-driven Flow Shear

Density peaking for ITG, ETG,…

High T_i/T_e for ITG (High T_e/T_i for ETG)

• q - profile control (RS) and shaping may remain effective in reducing transport in DEMO:

Precession reversal of trapped particles

Suppression of radially elongated steamers

Stabilization of NTM

Performance and Stability of RS plasmas

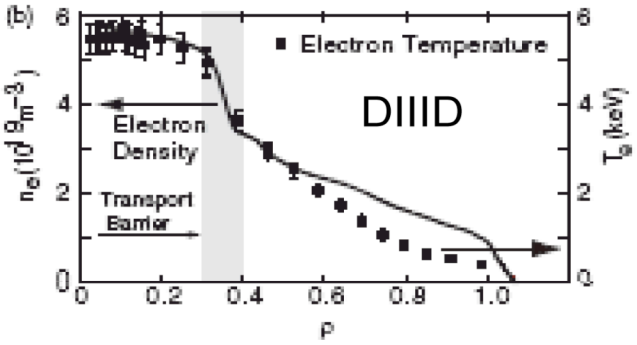
For $T_e \sim T_i$

- Either enhancement of confinement from ITBs for RS plasmas is modest [AUG 2000] or
- BOX-type profiles and radially localized reduction of χ_e

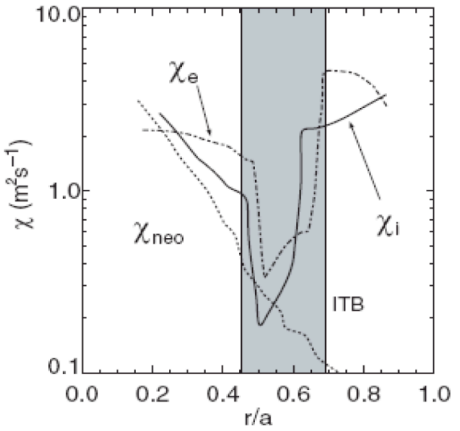
in strongly RS plasmas (JT-60U, DIII-D,…):

not ideal for performance

and macroscopic stability



JT-60U



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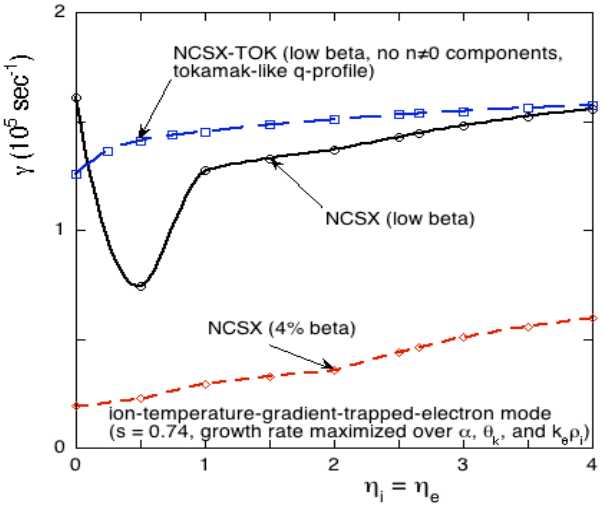
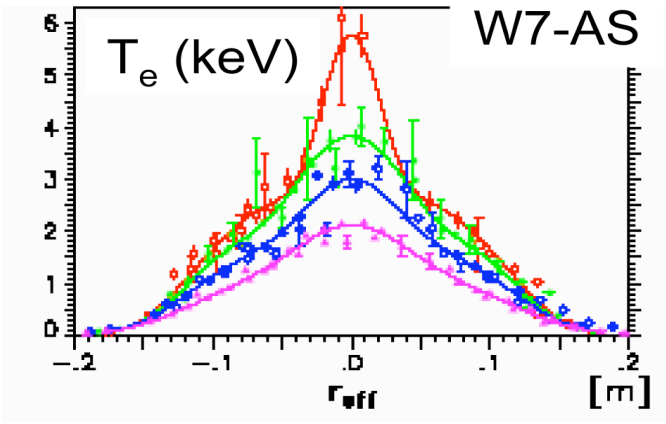
Transport reduction for wide region of plasma is required for both performance and MHD stability

How can we achieve χ_e reduction over a wide region?

Calculated core micro-stability in NCSX similar to that of tokamak RS plasmas.





$0.23 < P_{ECRH} < 1.23$ MW

Stellarator Electron Root Plasmas:

χ_e reduction for wide core region W7-AS, LHD, CHS, TJ-II

Electron Root occurs at high T_e/T_i and low n, but with significant hysteresis

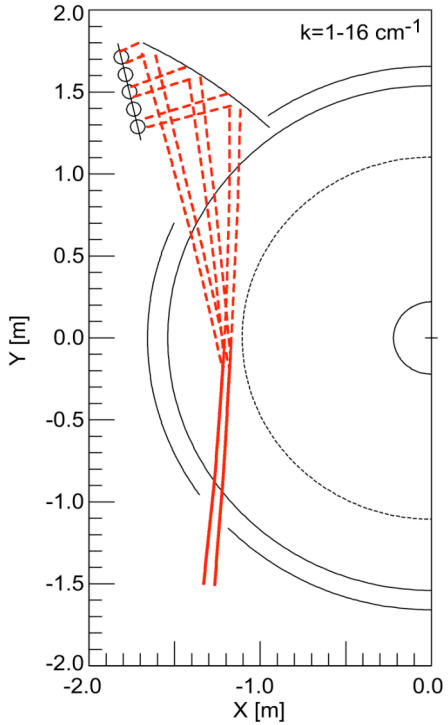
Can it be sustained for $T_e = T_i$ and high density in quasi-axisymmetric stellarators?

NSTX can address DEMO-relevant ITB physics issues

EPM can cause avalanche of α particle transport in RS region [Zonca, IAEA 2002]

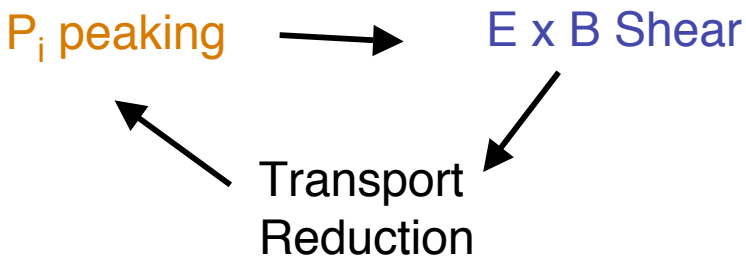
But, ρ^* for alphas in DEMO is significantly smaller than that of energetic ions in present day machines

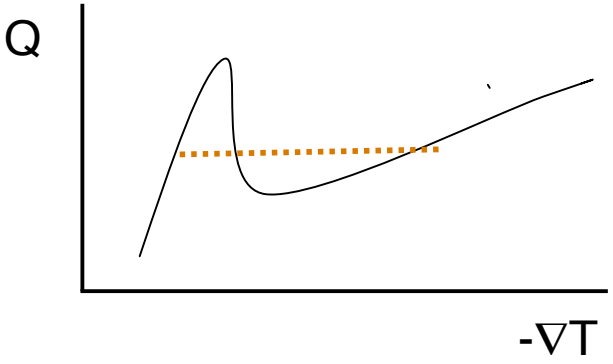
also for energetic electrons in NSTX
---> useful for α particle transport studies



NSTX: HHFW can produce near isotropic high temp electrons in RS
also equipped with excellent diagnostics capabilities including high-k tangential-scattering,
MSE, CHERS, reflectometry

Suggestions on H-mode Physics Studies





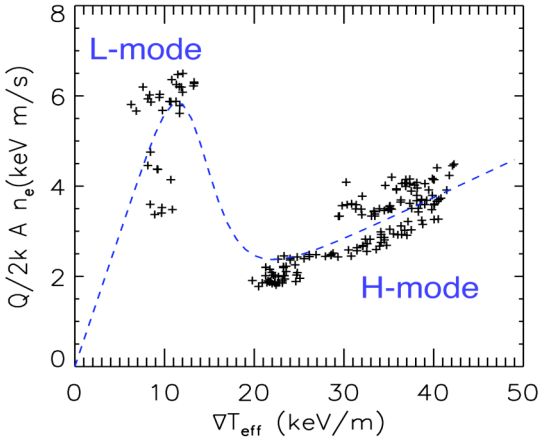
We still lack quantitative predictions on:
Trigger, Power Threshold, Pedestal Width,…

ITER and DEMO: tight margin on P_{LH}
Hysteresis can help (eg., H-mode entry at low n,…)

But experimental data need to be translated to common physics language.

e.g., Extension of characterization in terms of S curve to H - L back transition.

Flux Q/n vs T gradient measured on C-Mod during RF Power ramps



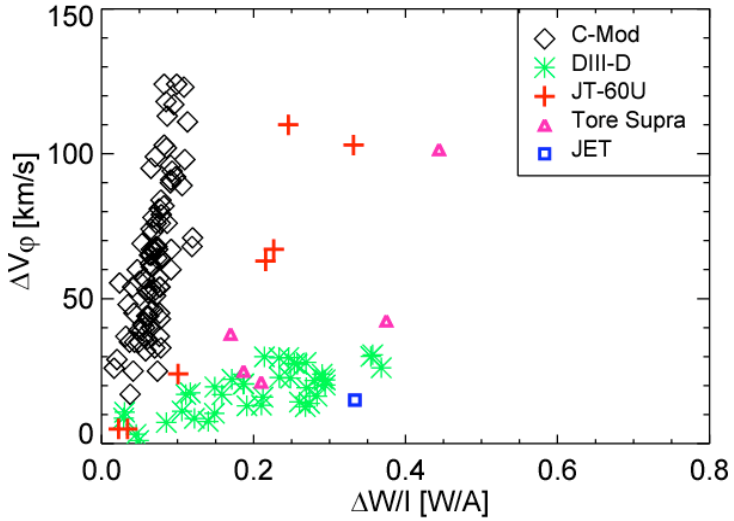
Spontaneous Toroidal Rotation

Important for RWM control and transport

Empirical scaling mostly based on
H-mode plasmas without NBI [Rice, NF 2001]
depends on stored energy, and I_p.

But size scaling unknown:
extrapolation to ITER and DEMO ?

High neutral opacity may limit pedestal width
and build up of spontaneous rotation?



Technical Support and Collaboration on IBW Flow Drive in EAST and KSTAR