NSTX

Supported by

U.S. DEPARTMENT OF ENERGY

Office of Science

XP933: NTV physics at varied $\nu_i^*/q\omega_E$ and search for offset rotation in NSTX

- *College W&M*
- *Colorado Sch Mines*
- *Columbia U*
- *Comp-X*
- *General Atomics*
- *INEL*
- *Johns Hopkins U*
- *LANL*
- *LLNL*
- *Lodestar*
- *MIT*
- *Nova Photonics*
- *New York U*
- *Old Dominion U*
- *ORNL*
- *PPPL*
- *PSI*
- *Princeton U*
- *Purdue U*
- *Sandia NL*
- *Think Tank, Inc.*
- *UC Davis*
- *UC Irvine*
- *UCLA*
- *UCSD*
- *U Colorado*
- *U Maryland*
- *U Rochester*
- *U Washington*
- *U Wisconsin*

S.A. Sabbagh[1], R.E. Bell[2], K.C. Shaing[3], J.W. Berkery[1], S.P. Gerhardt[2], J.M. Bialek[1], D.A. Gates[2], B. LeBlanc[2], J.E. Menard[2], K. Tritz[4], and the NSTX Research Team

[1]Department of Applied Physics, Columbia University, New York, NY, USA
[2]Plasma Physics Laboratory, Princeton University, Princeton, NJ, USA
[3]University of Wisconsin, Madison, WI, USA
[4]Johns Hopkins University, Baltimore, MD, USA

NSTX Results and Theory Review

September 15-16, 2009

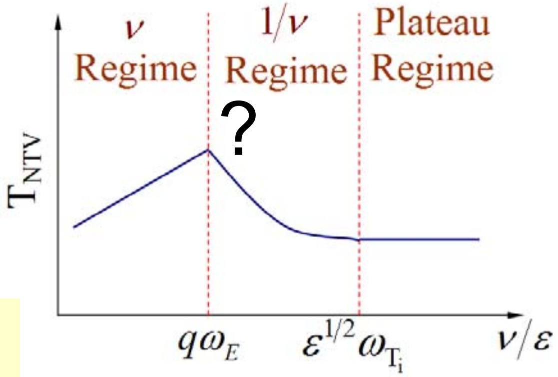
Princeton Plasma Physics Laboratory

- *Culham Sci Ctr*
- *U St. Andrews*
- *York U*
- *Chubu U*
- *Fukui U*
- *Hiroshima U*
- *Hyogo U*
- *Kyoto U*
- *Kyushu U*
- *Kyushu Tokai U*
- *NIFS*
- *Niigata U*
- *U Tokyo*
- *JAEA*
- *Hebrew U*
- *Ioffe Inst*
- *RRC Kurchatov Inst*
- *TRINITI*
- *KBSI*
- *KAIST*
- *POSTECH*
- *ASIPP*
- *ENEA, Frascati*
- *CEA, Cadarache*
- *IPP, Jülich*
- *IPP, Garching*
- *ASCR, Czech Rep*
- *U Quebec*

v1.1

XP933: NTV physics at varied $\nu_i^*/q\omega_E$ and search for offset rotation in NSTX

- **Motivation**
  - Determine key aspects of NTV physics to gain confidence in extrapolation to future devices
- **Goals**
  - Investigate damping over range of $\nu_i^*/q\omega_E$ to determine if the expected saturation of NTV at increased E_r actually occurs
    - Key for both low and high rotation devices (ITER, ST-CTF)
    - Does ST data reveal new physics, or revise applicability criteria?
  - Determine neoclassical offset rotation
    - NTV offset rotation found in tokamaks (Garofalo, 2008), but not yet determined in NSTX
    - Potentially important for low ω_ϕ devices (ITER)
    - Reversed I_p operation will allow better determination of offset rotation
- **Addresses**
  - NSTX IR(10-1) milestone
  - ITPA joint experiment MDC-12

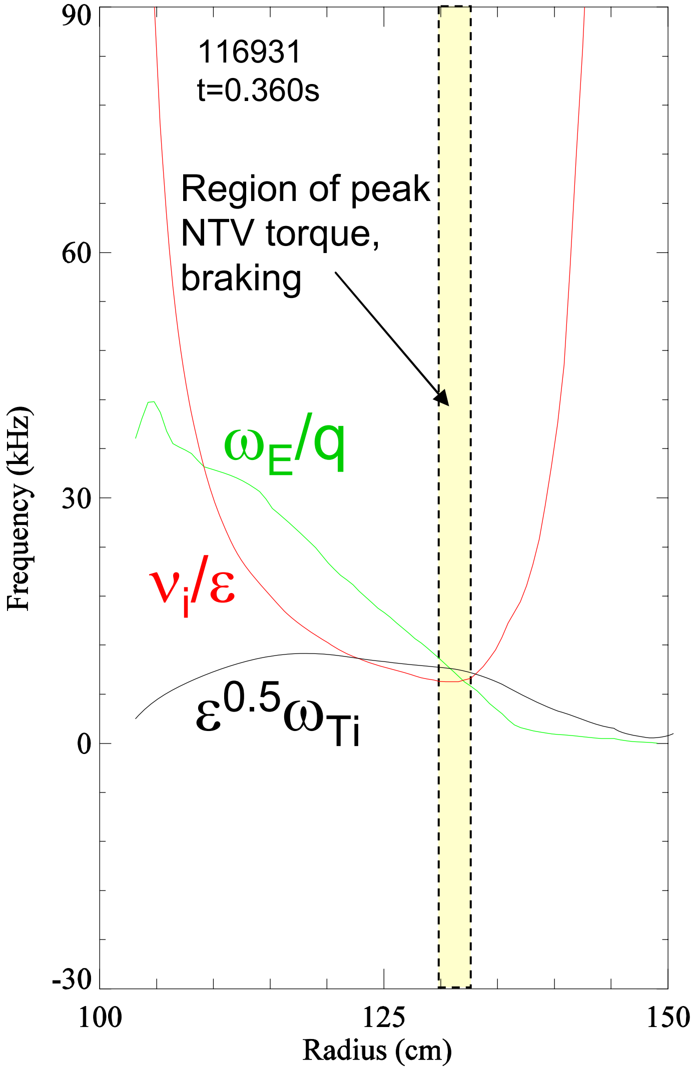


Does $1/\nu_i$ scaling $\rightarrow \nu_i/(\nu_i^2+\omega_E^2)$?

Utilize lithium and n = 1 EFC to study non-resonant braking over long timescale >> momentum diffusion time

- Past data
  - Non-resonant braking evolves into resonant braking, precludes accurate non-resonant NTV evaluation
- New approach
  - Utilize n = 1 EFC and lithium to delay or eliminate rotating n = 1 MHD
    - n = 1 MHD is the cause for strong resonant ω_ϕ damping
  - Examine braking from different initial ω_E ($\nu_i^* < 1$), at various R
    - Initial n = 3 braking field to vary initial ω_E, then increase braking
    - If $\nu_i^*/q\omega_E(R) > 1$, should observe $T_i^{5/2}$ scaling
    - If $\nu_i^*/ q\omega_E(R) < 1$, should observe saturation in braking, or other (?) scaling
  - Look for NTV offset rotation ($T_{NTV} \sim \delta B^2(\omega_\phi - \omega_{\phi-\mathrm{offset}})$)
    - Allow second quasi-steady-state ω_ϕ to be reached after 2nd braking pulse; will data support existence of $\omega_{\phi-\mathrm{offset}}$? (a counter-$I_p$ offset)
    - Supplement co-injection data with *counter-injection* data - best conclusion

Past NSTX data shows a small region of applicability for NTV collisionless regime scaling



- n = 3 braking "configuration
- Frequency profiles
  - Collisionless NTV formulation valid in region of peak measured damping where $q\omega_E < \nu_i/\varepsilon < \varepsilon^{0.5}\omega_{Ti}$
  - Computed/observed damping near boundary (low T_i, collisional regime) typically far weaker
  - Uncertain if $\omega_E < \varepsilon^{0.5}\omega_{Ti}$ criterion is required for collisionless damping
    - Adequate criterion to describe NTV saturation due to E_r effects?
    - the ω_E calculation neglects poloidal flow and uses carbon ω^*, may be overestimated

XP933: NTV physics at varied $\nu_i^*/q\omega_E$ and search for offset rotation in NSTX – Brief Status

- Status
  - NTV braking observed from all initial $\nu_i^*/q\omega_E(R)$ variations made in experiment (n = 3 configuration)
    - Strong braking observed with lithium, saturation of braking not observed
  - Braking of resonant surfaces appeared in many instances, but without locking, even at very low plasma rotation
    - This, and stronger NTV braking at increased T_i correlate with Li operation
  - Apparent lack of $1/\omega_\phi$ scaling of drag torque on resonant surfaces
    - Provocative result – either island width is decreasing at low ω_ϕ (why?), or drag at island caused by "island NTV" ~ ω_ϕ (K.C. Shaing, PRL **87** (2001))
  - No clear NTV offset rotation (yet)
    - Further analysis needed. If $\omega_{\phi\text{–offset}}$ exists, it would appear to be small
    - Difference between C and D rotation at low values of V_ϕ to be examined
- Quantitative analysis is next step
  - First results for ITPA MHD October '09 meeting