Characterization of GAE modes and their effect on electron thermal transport

Joint T&T-WPI XP Proposal

The JHU Plasma Spectroscopy Group

NSTX Group Meeting
May 4th 2009

Motivation:

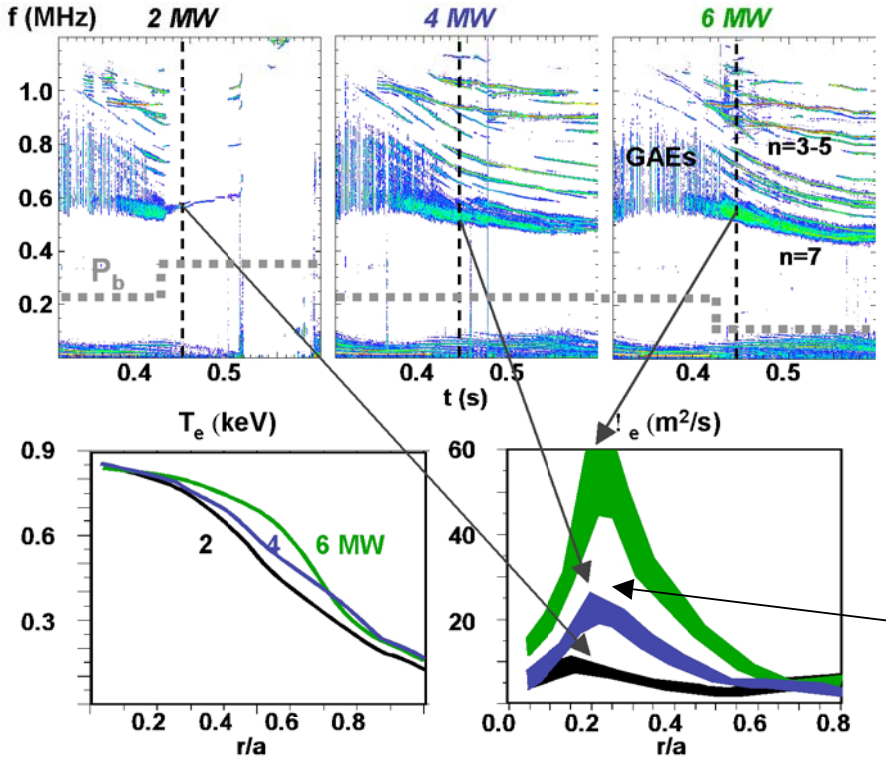
- Flat electron temperature profiles on NSTX have no explanation

- No temperature/density gradients to drive turbulence

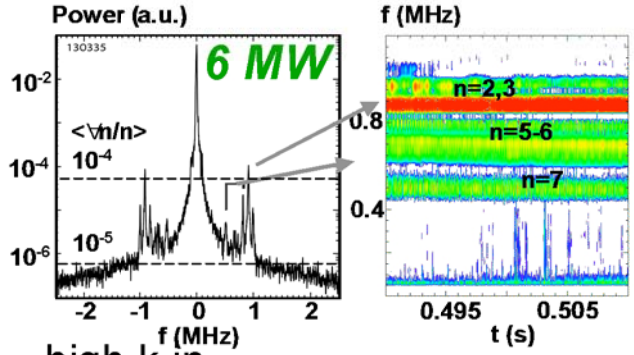
- Fast ion gradients can drive energetic particle modes

- Possible connection between GAEs and electron thermal transport

GAE/electron transport correlation observed using P_b steps



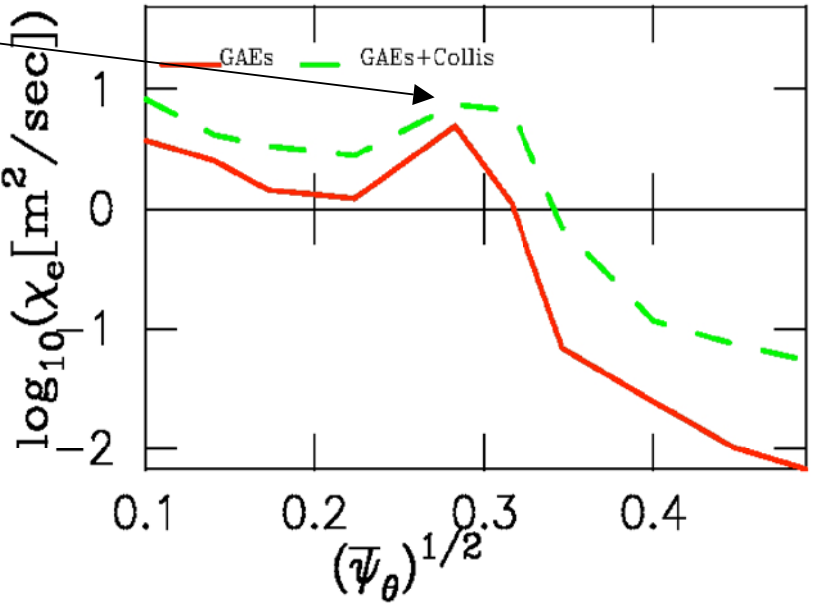
E. Mazzucato



high-k in interferometric mode

magnetics

N. Gorelenkov



- P_b steps at fixed q(r), n_e, ω_{ExB}
- GAE $\langle\delta n\rangle/\langle n\rangle \leq 1.5\ 10^{-4}$ at 6 MW
- Theory predicts χ_e peak at r/a~0.25

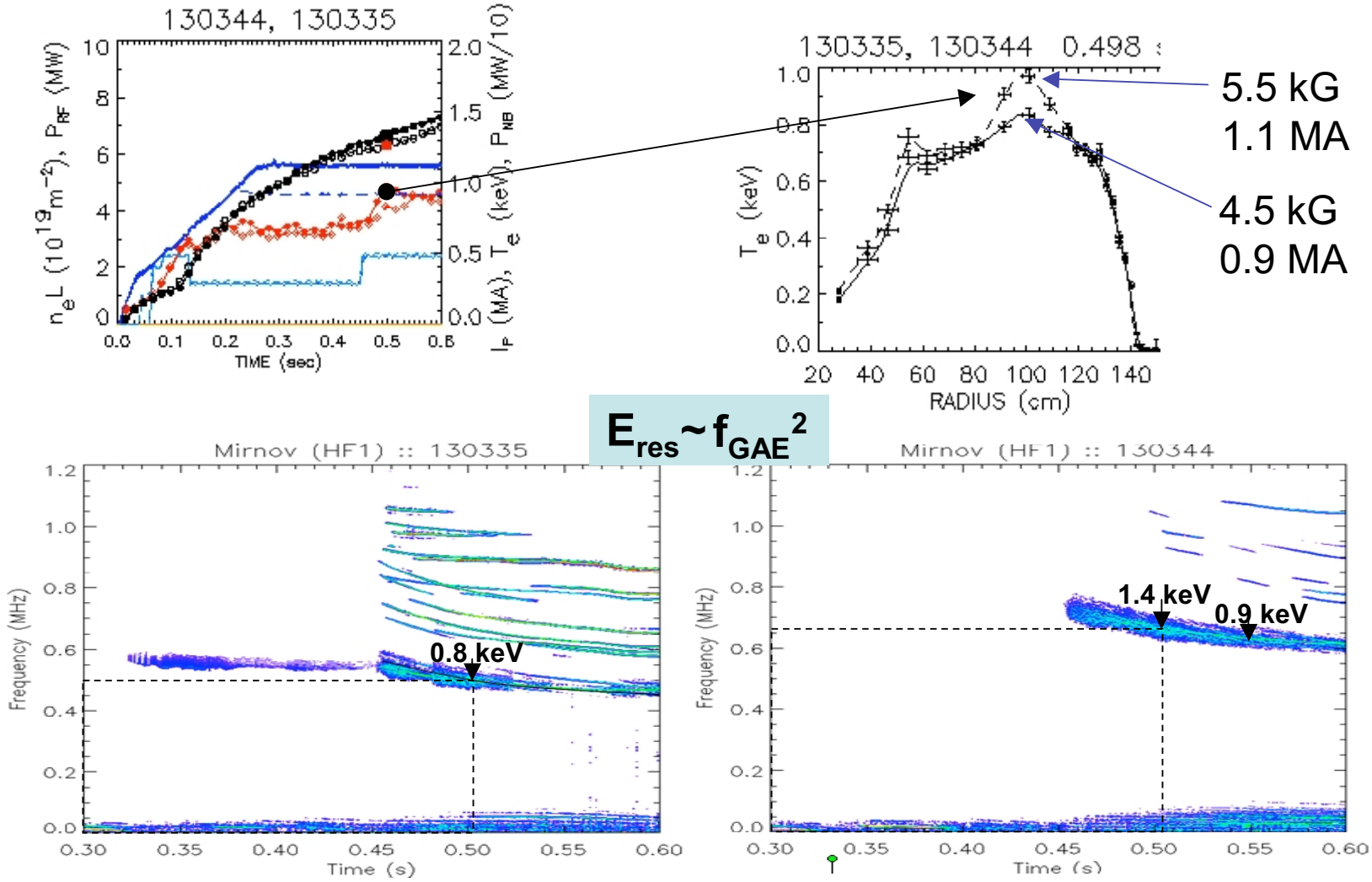
Part I: Characterization of GAE mode structure/amplitude

- Simulations have many free parameters
- Mode structure measurements will better constrain codes
- Improved transport predictions to compare with observations

- Use high-k (inter.) and FIReTIP (upgrade?) for internal measurements
- Detailed radial high-k scans 110-130cm provide amplitude/structure
- Change beam power steps to modify GAE amplitude and turbulence

- Scan beam power (ref shot 130335): 3(2) MW 4.5(4)MW 6MW
- Measure GAEs using FIReTIP, high-k at 113, 118, 123, 128cm
- 12 shots (x2 for statistics) ~24 shots: 1 day - repeatability crucial!

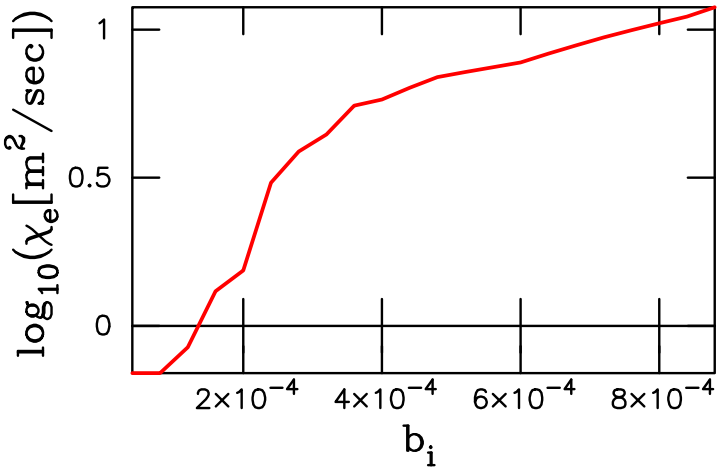
Higher GAE frequency at high B_t allows transient T_e peaking?



- Broad band of higher frequency GAEs at high field
- Resonance with higher energy electrons might allow transient Te peaking

Parallel electric field can strongly enhance χ_e

Baseline case, $\nu_e/\omega_{ce} = 0$, $r/a = 0.22$, $\alpha_0/R = 4 \times 10^{-4}$.



- Ideal MHD is assumed, but
- $E_{||} = \nabla\Psi$ is included perturbatively via the quasi-neutrality condition due to thermal ion FLR

$$\Psi = \phi_{MHD} \frac{b_i}{1 + b_i}, \; b_i = \frac{k_\perp^2 \rho_i^2}{2},$$

$b_i \sim 0.5 \times 10^{-4}$ in NSTX, ϕ_{MHD} is such that $E_{||} = 0$.

Other source of $E_{||} \neq 0$ is from two fluid effects, compressibility (~ b_i)

Beam ions do not contribute.

KAW can only if $\omega > \omega_A$ similar to stellarator GAEs (Kolesnichenko, PRL'05). Can they exist in tokamaks?

Part II: Dependence of transport on GAE frequency

- GAE frequency-electron energy resonance depends on field
- Change in resonance may change electron transport, Te profile
- Field scan may also identify/isolate effect of $E_{||}$

- Detailed mode structure measurements needed (high-k scan)
- Radial high-k scans 110-130cm provide amplitude/structure
- Change Bt, Ip for field scan at constant q

- Scan fields at constant P_{NB}: .4T / 8MA, .47T / .95MA, .55T / 1.1MA
- Measure GAEs using FIReTIP, high-k at 113, 118, 123, 128cm
- 12 shots (x2 for statistics) ~24 shots: 1 day (total: 2 days)

Likely moderate ~10-15 mg/min Li deposition
(repeatability, MHD quiescence)

Day 1

Establish reference:
130355, 6MW
Ip 0.9MA, Bt .45T **2**

GAEs present?
no Low-f MHD?

Scan beam power
130355, 2 (3), 4 MW
high-k @ 113cm **4 (6)**

if no GAEs at 2MW,
use 3MW

high-k -> 118cm
repeat NB scan
(6, 4, 2(or 3) MW) **6**

repeat scan for
high-k 123, 128cm **12**

total = 24 (26) shots

Day 2

Use 'best' result from
Day 1 (6 MW?)
high-k @ 113cm **2**

GAEs present?
no Low-f MHD?

Scan fields
Ip -> 1.1 / 1 / 0.8MA
BT -> 5.5 / 5 / 4T **6**

high-k -> 118cm
repeat field scan **6**

repeat scan for
high-k 123, 128cm **12**

total = 26 shots