XP-1068:

RF Amplification of EHOs in Lithium-pumped ELM-Free Plasmas

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Team Review

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Houston, We have a Problem

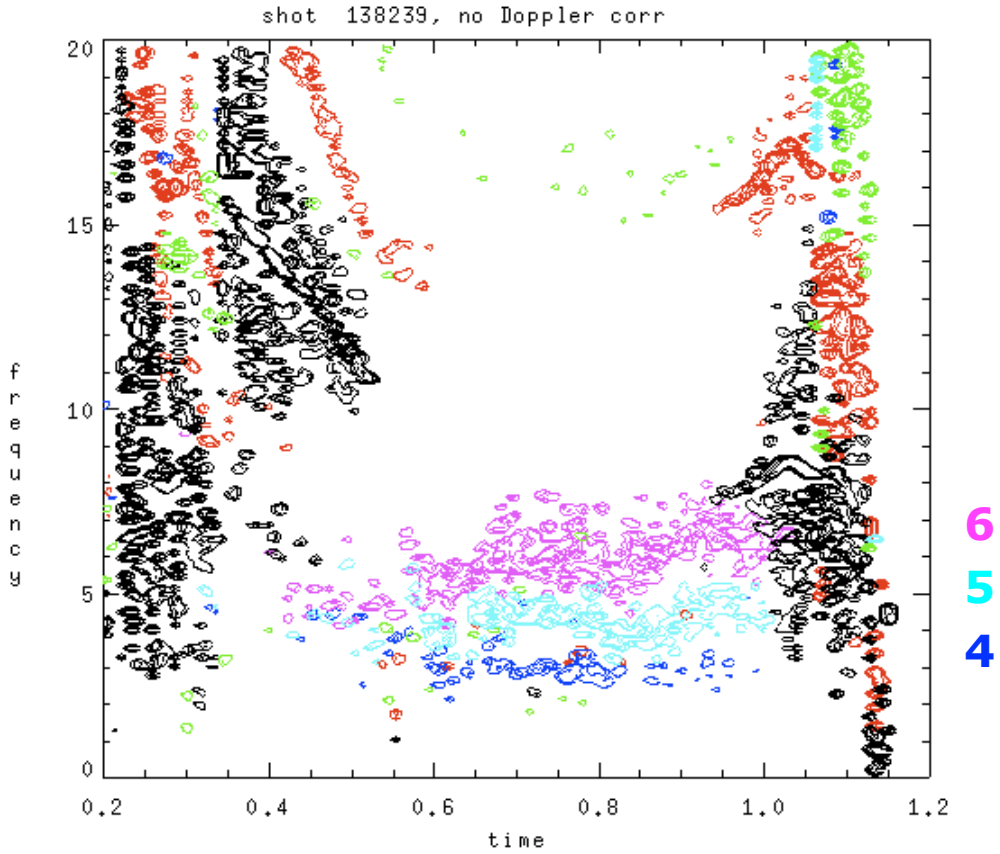
- Lithium is effective at holding the deuterium density constant.
- But the carbon density keeps rising.
- Core radiation rises.
- This is not good, but it is not because the lithium is not doing its job.
- In the absence of ELMs the plasma has no way to unload impurities.

Are EHOs the Answer?

- DIII-D has found QH modes with strongly rotating co plasmas.
- These plasma are a little tricky to make, they require high edge rotational shear.
- The density does not rise, however, in these plasmas, despite absence of ELMs.
- They believe that Edge Harmonic Oscillations (EHO's) are the reason.

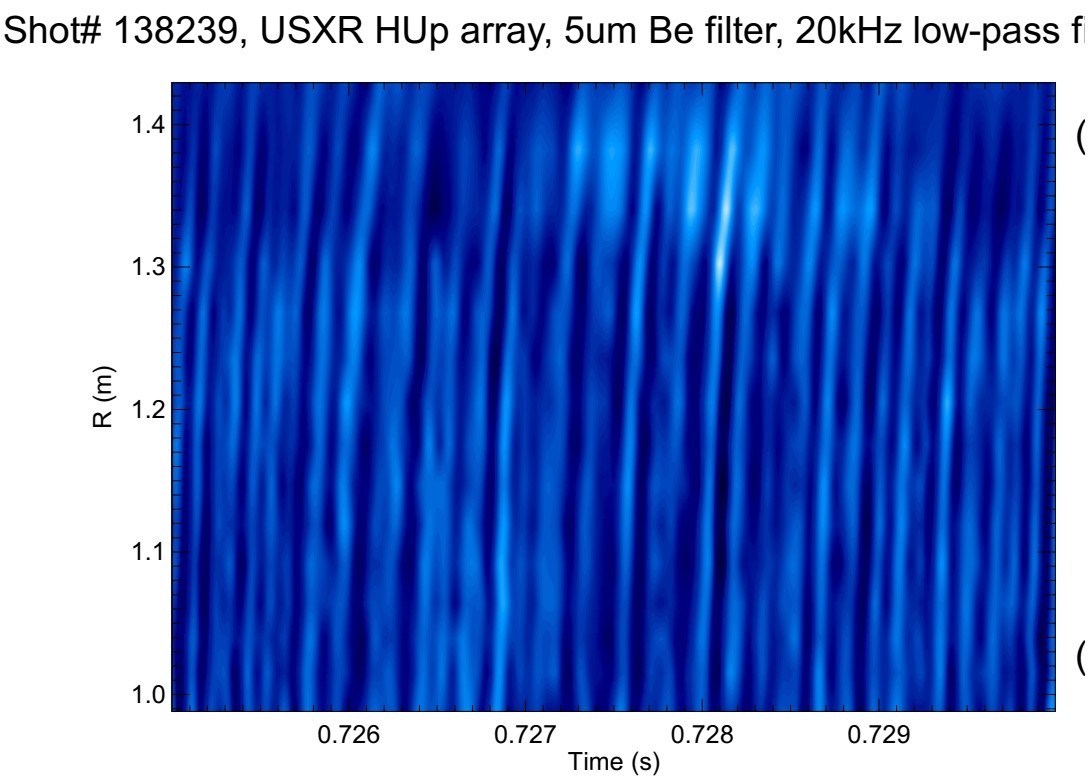
We See EHOs on Mirnov Coils

- **Eric's MODE code**
- **Tuned for low frequency (long samples)**
- **Tuned for low amplitude (measures dB/dt)**



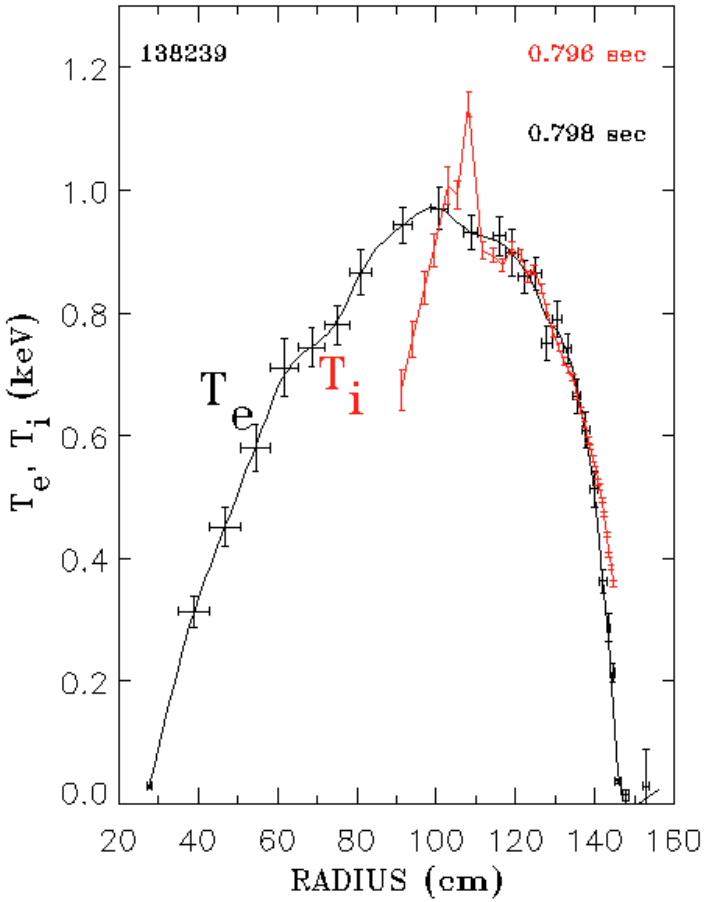
- **Studied current, field and power scans from XP - 1043.**
  - ELM-free, lithiated
- **Best cases are 4 MW, 800 kA, 4.5T**
- **Need a time window between n = 1 modes early and late**
- **Not claiming that EHOs reduce density rise (yet)**

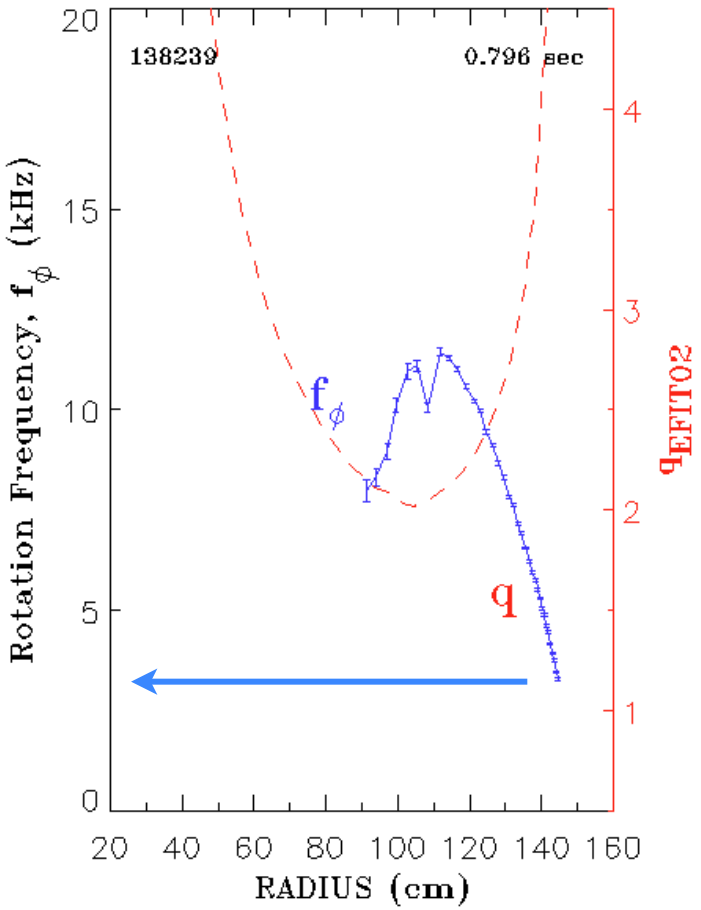
We See EHOs on USXR



- **Kevin Tritz / Johns Hopkins**
- **FFT by eye gives ~6 kHz**

We Have Serious Edge Rotation Shear





The shear at 1 kHz must be pretty impressive

Propose to Modify EHOs Using Modulated HHFW

- **Easy to amplitude modulate HHFW**
- **HHFW couples to the edge plasma in ways we don't completely understand**
- **Maybe we can use it to drive EHOs and even control impurity influx.**
  - Evidence of coupling would motivate theory.
- **If RF coupling doesn't work, hook up SPAs to HHFW antenna? Much harder experimentally, easier to understand theoretically. Do modulated RF first.**
- **C-MOD has a Mini-Proposal to use modulated ICRF to drive their QCMs, at much higher f.**
- **BOY WOULD THIS BE A GOOD RESULT FOR ITER.**

Proposed Run Plan

I Establish conditions similar to 138239:

- Establish the presence of EHOs both on the Mirnov and soft X-ray systems
- Measure impurity accumulation

  3 shots

II Add Amplitude-Modulated HHFW Power

- Determine level of power and pulse length that can be reliably obtained. Don't need to push to the highest power levels, which would make this unreliable.
  3 shots
- Establish level of amplitude modulation that can be obtained at observed frequency of strongest EHO ~ 4 kHz.
  3 shots
- Sweep frequency of amplitude modulation from 0.5 – 7.5 kHz, and determine where maximum amplification occurs.
  3 shots

III Maximize effect

- Select optimum point for EHO amplification, if some is observed, and maximize modulated RF power. By looking at the swept results may decide to have some sweeping still in this case. Interleave with shots with same RF power but no amplitude modulation.
  6 shots

Required Capabilities

- Lithium evaporation, 4 MW of NBI power, 800 kA, LSN
- Best if this happens soon after HHFW experiments have established reasonably healthy operations - preferably with 4 MW NBI, 800 kA, LSN, Lithium evaporation
- Need Mirnov array, soft-x-rays, rotation, and impurity accumulation measurements, divertor heat flux

Planned Analysis

Will examine impurity accumulation as a function of EHO strength. Will use results to motivate theoretical analysis of coupling of HHFW power to EHO's. If the result is that there is no change in the amplitude of the EHO's, then will need to consider near-field "inductive" audio drive.

It would be valuable also to observe any change on the divertor heat flux. It could go up due to reduced radiative power, or go down (in the most favorable case) due to increased edge oscillation.

Positive result -> PRL