Evidence of Parametric Decay during HHFW Heating on NSTX

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NSTX Results Review

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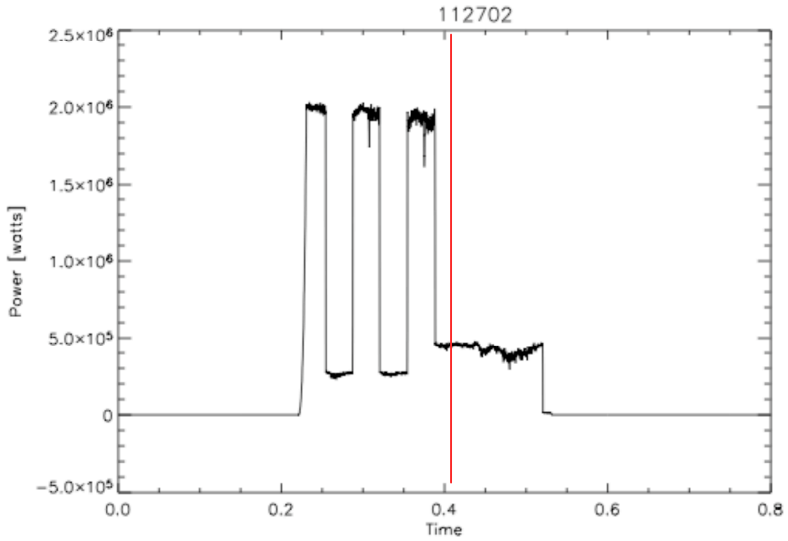
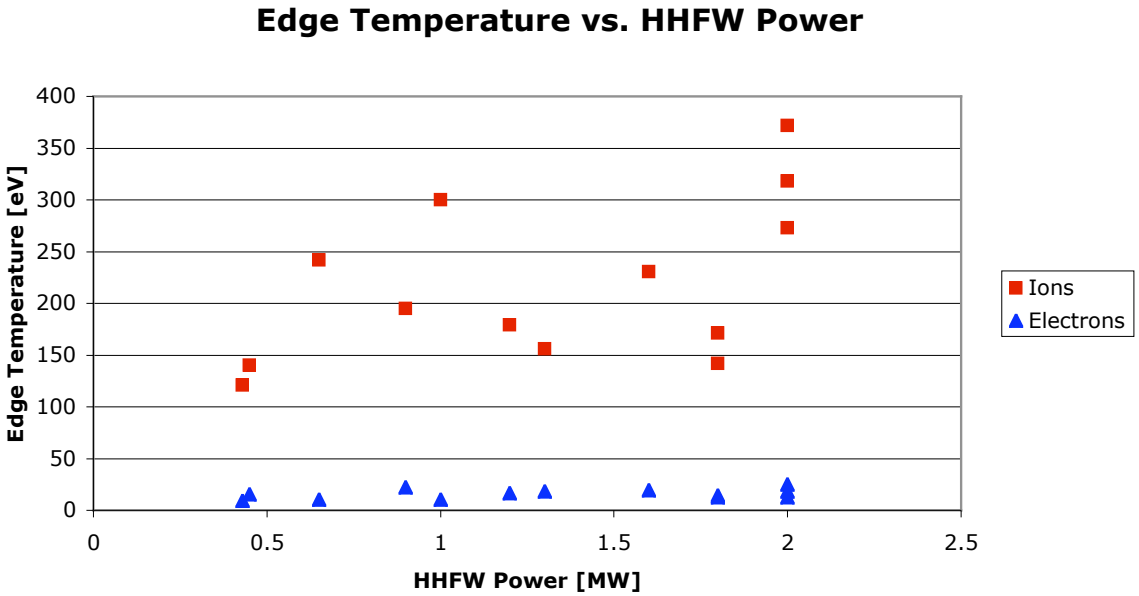
XP 441 Conditions

- Plateau P_{HHFW} was varied between 0.4-2 MW
- Helium and deuterium plasmas with phase 14 or 7 m^{-1}
- Quantities calculated at t = 0.4 s



Unexpected Behavior has been Observed during HHFW Heating

- Edge rotation and impurity heating has been observed

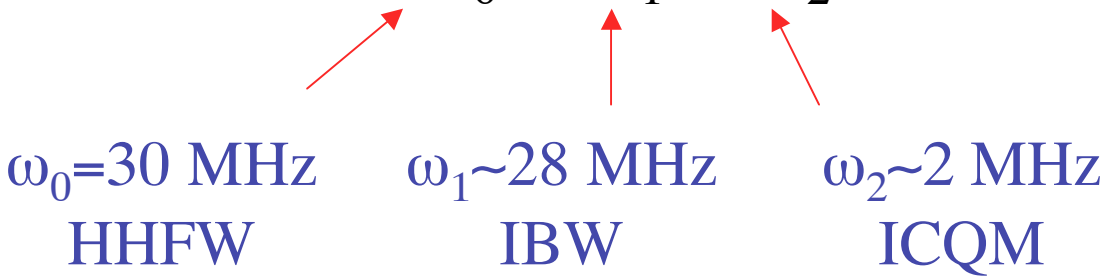


- One possible explanation is parametric decay

Parametric Decay Theory

- Nonlinear three wave coupling process with selection rules:
  - Conservation of Energy

$$\omega_0 = \omega_1 + \omega_2$$



  - Conservation of Momentum

$$k_0 = k_1 + k_2 \rightarrow k_1 = -k_2$$

- Energy is deposited within 10 cm of the plasma edge

Evidence of Parametric Decay

- A Langmuir probe has been installed on NSTX to look for evidence of parametric decay
- The ICQM cannot be detected because of equipment limitations
- Look for characteristic IBW peaks:

$$f = f_0 - n\Omega_i$$

IBW

HHFW

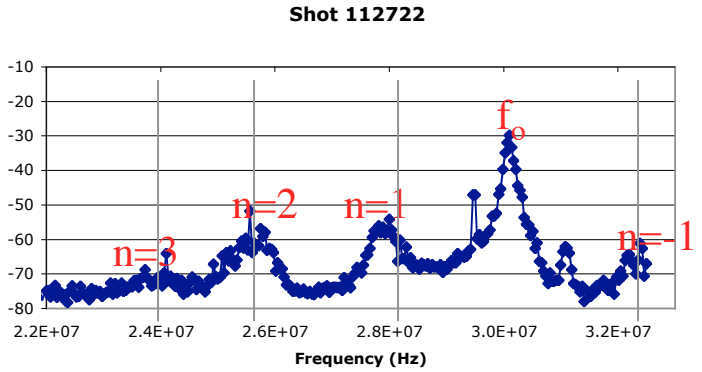
Harmonics of Ω_i for He or D

Characteristic Peaks Observed

- Both upper and lower sidebands were observed
- As the power was increased, more sidebands were visible

Deuterium Plasmas:

- $+\Omega_\iota$ seen for P_{HHFW} >1 MW



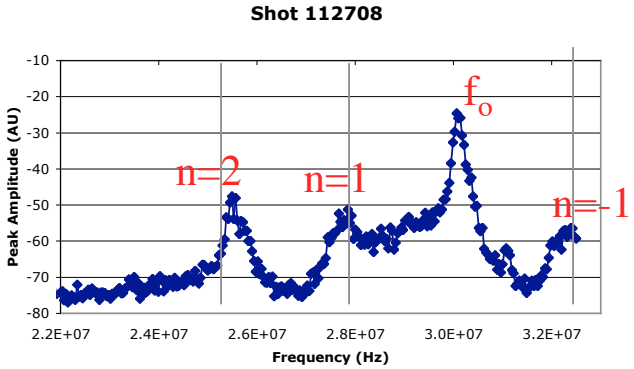
Helium Plasmas:

14 m^{-1}

- $-2\Omega_i$ visible for P_{HHFW} >0.65 MW
- $-3\Omega_i$ visible for P_{HHFW} > 1.3 MW

7 m^{-1}

- No n=3 peak

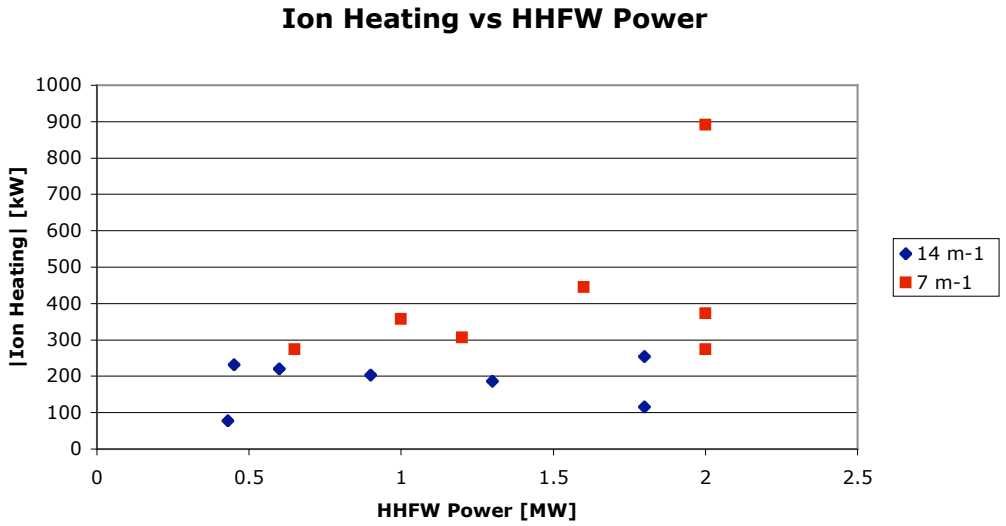


Estimate of Parasitic Power Going into Edge Ions

- Cannot measure power from Langmuir probe
- Estimate amount of power needed if collisional heating was the process
  - This gives a lower bound

$$Q_i = \frac{3m_e}{m_i}\frac{nk}{\tau_e}(T_e - T_i) \quad \text{where:} \quad \tau_e = \frac{3\sqrt{m_e}(kT_e)^{3/2}}{4\sqrt{2\pi}n\lambda e^4}$$

- Collisional ion heating increases with P_{HHFW}

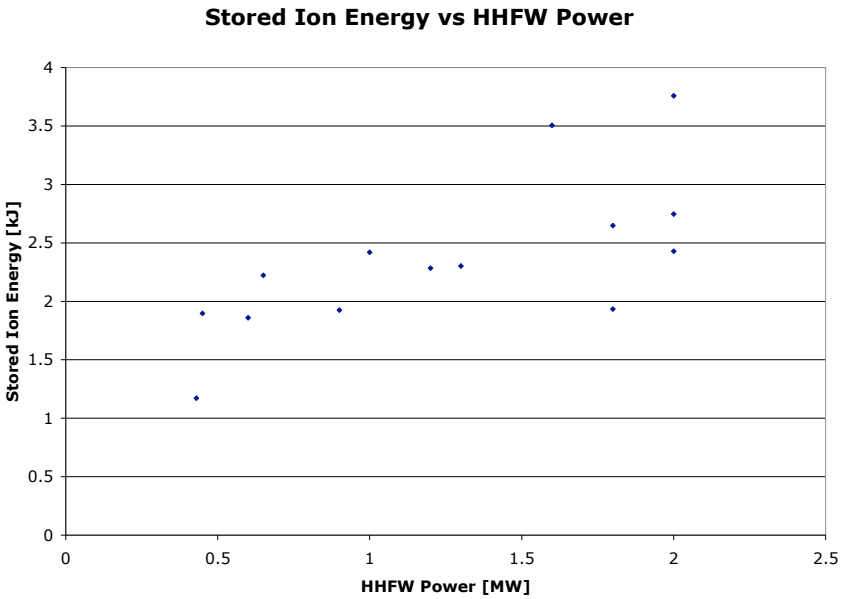


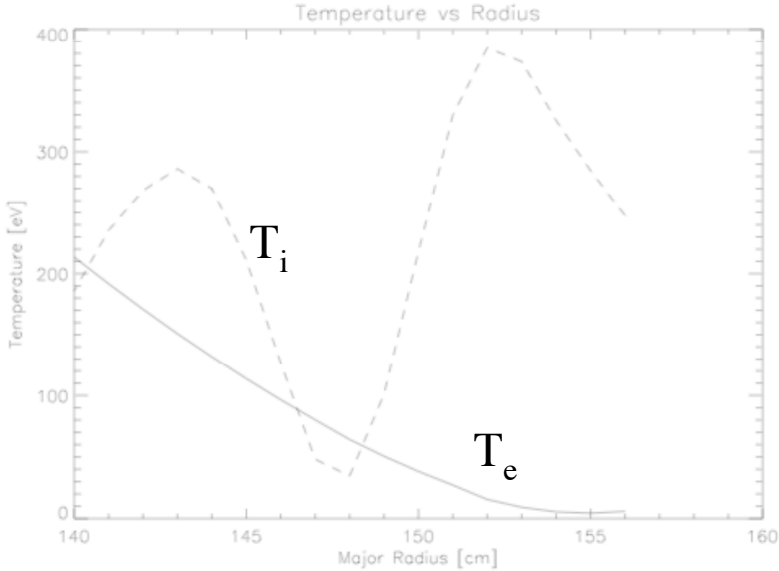
Conclusions

- HHFW is expected to heat core electrons
- New observations show edge ion heating during HHFW operation
- Theory states that the HHFW should parametrically decay into an ICQM & IBW
- Evidence of parametric decay seen in NSTX He and D plasmas - IBW has been detected
- An increase in power yields more IBW sidebands
- Estimated power going into ions increases with P_{HHFW} increase

Ion Heating in Edge Observed

- Stored energy in ions increases P_{HHFW}





Ion Temperature with Phase Information