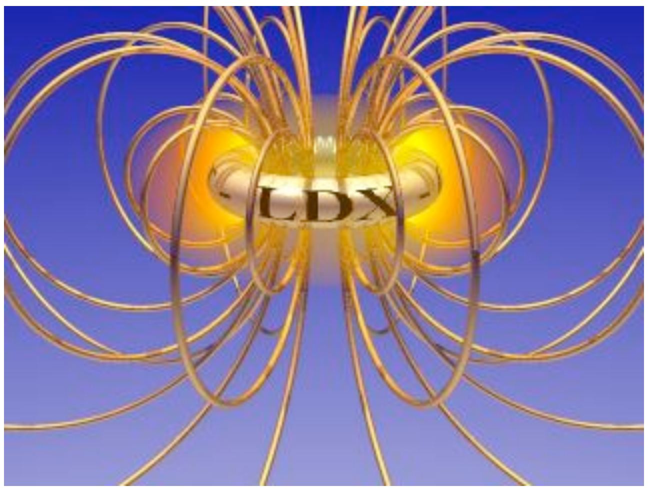
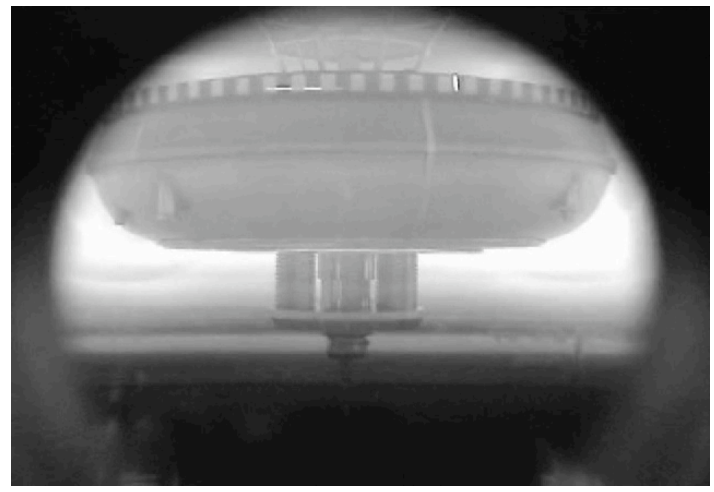


Low Frequency Fluctuations During Levitated Operation in the LDX Plasma

J.L. Ellsworth, A.C. Boxer, J. Kesner, MIT PSFC
D.T. Garnier, M.E. Mauel, Columbia University



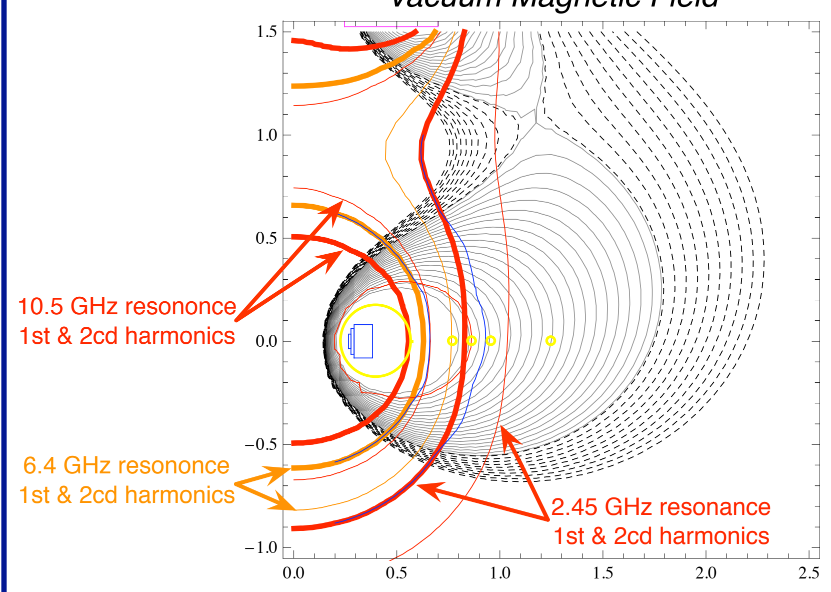
Observations

- Low-frequency (0.5-10kHz) fluctuation was previously observed in LDX plasma with the internal coil supported [1].
- Low-frequency fluctuation has now been observed in LDX plasmas with the internal coil levitated.
- The fluctuation frequency is in the range of 500 Hz when the is heated only by 2.45 GHz.
- The fluctuation frequency increases to a few kHz when multiple frequencies of RF are used to heat the plasma.
- We sometimes observe different fluctuations in the core of the plasma than at the edge.
- Fluctuations observed at the edge have a toroidal mode number of 1 and a large radial extent.

[1] Garnier et al, to be published in J. Plasma Phys. (2008)

The Levitated Dipole Experiment

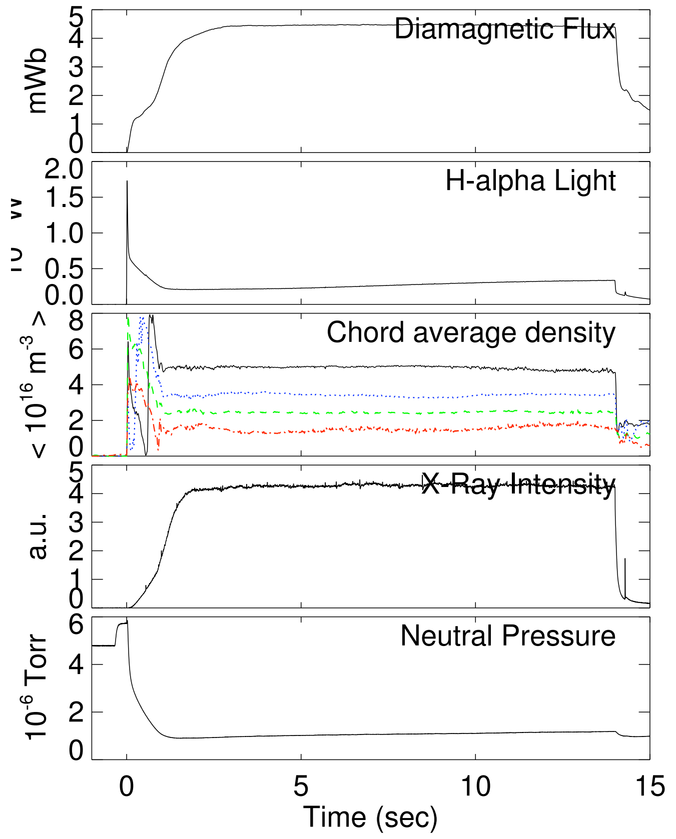
Vacuum Magnetic Field



See adjacent poster P.046 by Mike Mauel

- Multi-frequency electron cyclotron resonance heated plasmas
- Plasma contains fast electrons that carry most of the pressure
- Diagnostics include a 4-channel interferometer, electrostatic probes, Mirnov coils, flux loops, photodiodes, x-ray intensity detector, and visible cameras

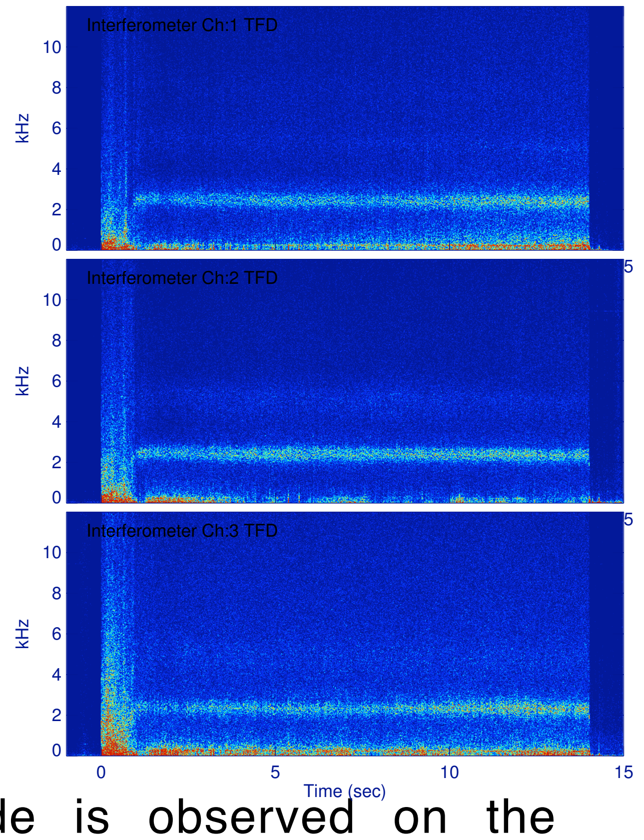
Quasi-coherent modes with frequencies of 1-10 kHz are observed during multi-frequency ECRF heating

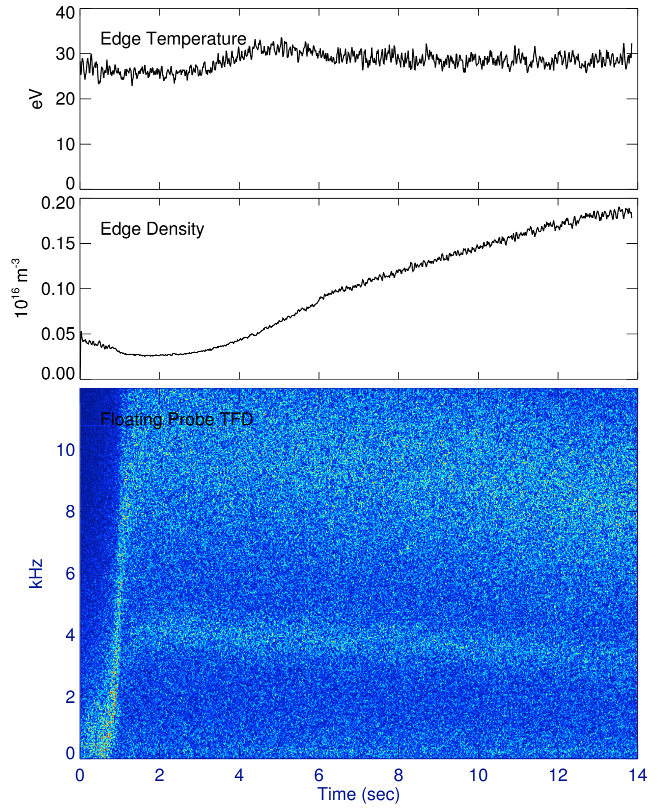


This plasma is heated from 0-14 seconds with 2.5 kW of 2.45 GHz ECRF and 9 kW of 10.5 GHz ECRH. The plasma is fueled by a helium puff at t=-0.1 seconds. No additional fueling is injected. The RGA indicates that the neutral partial pressures of helium and deuterium are approximately equal. The plasma is in a steady state from t~3 s until the heating power is turned off.

Left: Temporal information about the plasma. Diamagnetic flux measured by a loop near the mid-plane. H-alpha light measured by an uncollimated photodiode. Chord-averaged density for the 4-channels of the interferometer. X-ray intensity. Neutral pressure measured by the ion gauge.

Right: Spectrograms showing the amplitude of fluctuations as a function of frequency and time for the 3 innermost channels of the interferometer. Notice that a quasi-coherent mode is visible on all 3 channels after the plasma density has settled into a steady state. The second harmonic is present but very faint.

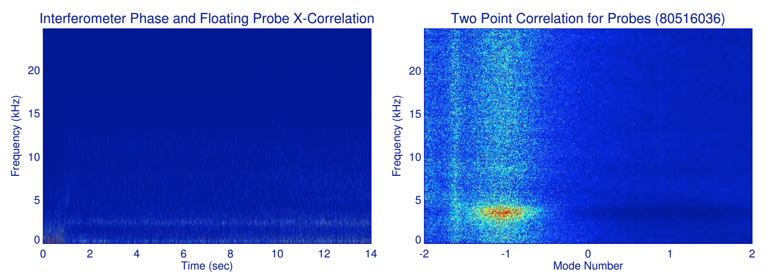




A 2.5 kHz mode is observed on the interferometer which views the core of the plasma. Their is a weak correlation at this frequency between the interferometer and the floating probes that view the edge of the plasma. The probes see a 4.5 kHz mode that decreases in frequency as the plasma evolves. This mode is also visible on the Mirnov coils. Both diagnostics indicate a toroidal mode number of 1 in the direction of the diamagnetic current.

Above: Spectrogram of a floating probe located at the edge of the plasma. A mode wis visible that has decreasing frequency as the plasma evolves.

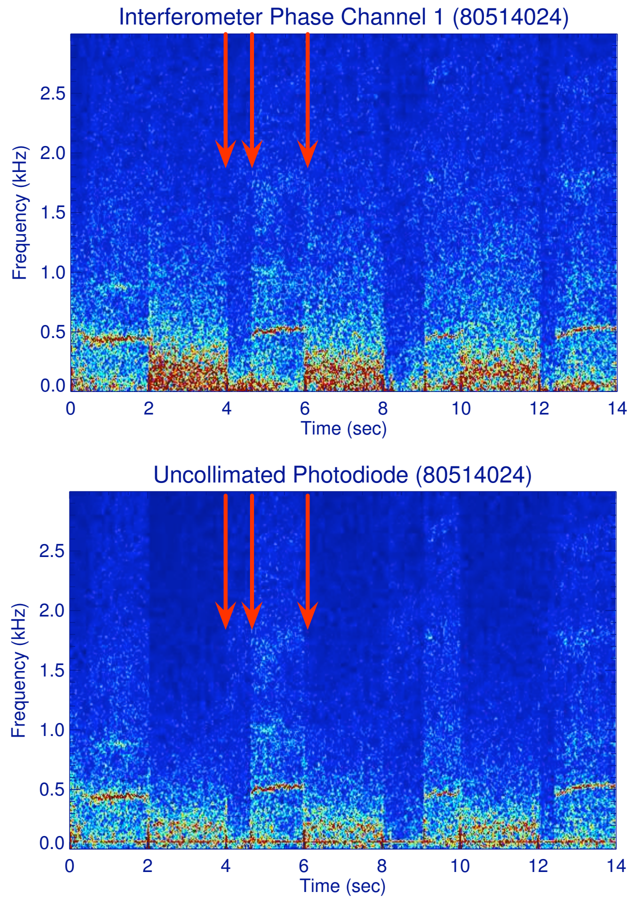
Below: Two point correlation from floating probes separated by 90 degrees shows the fluctuation has a toroidal mode number of 1.

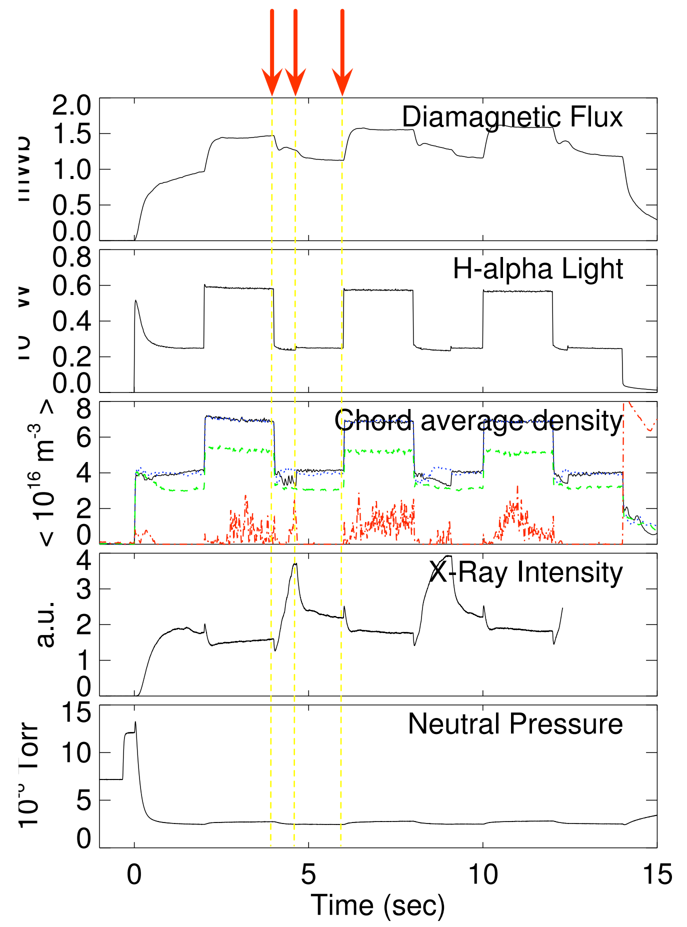


500 Hz mode observed on diagnostics that view the plasma core during 2.45 GHz only heating

See also talk Alex Boxer

This plasma is fueled by D2 gas and heated by 2.5 kW of 2.45 GHz heating. Several times during the shot, the plasma is heated with an additional 2.5 kW of 6.4 GHz heating. The additional heating leads to increased flux, increased density, and increased radiation. In addition the shape of the density profile changes with the additional of a 2cd heating frequency. When the 6.4 GHz heating is turned off, we see an abrupt decrease in broadband fluctuations and the density profile remains perturbed then spontaneously relaxes to a less peaked profile. When this occurs, we see an increase in broadband fluctuations and a 500 Hz quasi-coherent mode is visible on the innermost channel of the interferometer. This mode is also captured by the uncollimated photodiode.





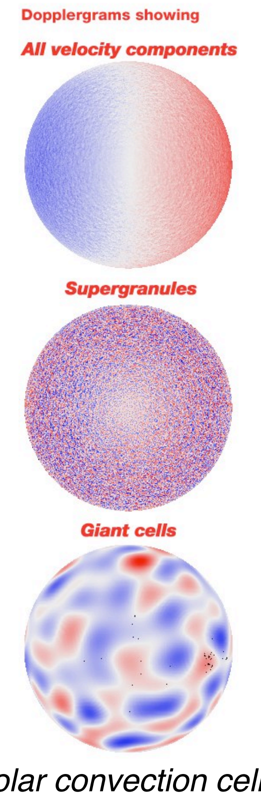
Upper left: Spectrogram of innermost interferometer channel. Lower left: Spectrogram of uncollimated photodiode. Rigth: Temporal information about the plasma. Diamagnetic flux measured by a loop near the mid-plane. H-alpha light measured by an uncollimated photodiode. Chord-averaged density for the 4-channels of the interferometer. X-ray intensity. Neutral pressure measured by the ion gauge.

Fluctuations may result from rotating convective cells or a drift frequency mode

- **Convective cells** can form in closed field line magnetic geometries.
- In a dipole, they circulate particles between the core and the edge
- Can be of any scale

- **Entropy mode** is a flute-like drift frequency mode.
- Present at all collisionalities
- $\omega \sim \omega^{*} \sim \omega_{d}$
- ω increases with increasing ∇n_e and T_e

See J. Kesner's poster for more dipole theory



Solar convection cells Credit: D. Hathaway, NASA/Marshall Space Flight Center

Need More Spatial Resolution!

Improved visible light diagnostics are available for the next run.

- Two fast photodiode arrays
  - Preamplifier has been completely redesigned to increase gain and reduce noise
  - New radial views apart will allow measurement of radial and toroidal mode number.
- Phantom fast camera
  - Image more plasma with new view
  - New lens for faster operation