Magnetic Fluctuations Associated with Electrostatic Drift-Wave Turbulence

K.W. Gentle, Jakub Felk1, Kevin Lee, Dylan Miracle

Fusion Research Center
University of Texas
Austin
The Helimak exhibits classic drift-wave turbulence in the region of density gradient with unfavorable magnetic curvature, $\beta < 10^{-4}$.

Despite electrostatic physics, magnetic fluctuations are associated with the drift-wave turbulence.

These (weak) fluctuations should be a good test of $j_||$ in the drift-wave model.
A Cylindrical Slab

Plates with surface probes
Helimak Dimensions and Parameters

A Sheared Cylindrical Slab

\(<R> = 1.1 \text{ m} \quad \Delta R = 1 \text{ m}\)
\(h = 2 \text{ m}\)
\(B_T = 0.1 \text{ T}\)
\(B_v \leq 0.01 \text{ T}\)

Pulse \(\leq 60 \text{ s}\)

Plasma source and heating: \(6 \text{ kW ECH} \quad \text{at} \ 2.45 \text{ GHz}\)
\(n \leq 10^{11} \text{ cm}^{-3}\)
\(T_e \sim 10 \text{ eV}\)
\(\beta \sim 3 \times 10^{-5}\)

Helium, neon, argon, xenon

\(c_s = 3 \times 10^4 \text{ m/s (Argon)} \quad V_{\text{drift}} = 100 \text{ m/s} \quad V_{\text{diamagnetic}} = 10^3 \text{ m/s}\)

\(v_{\text{drift-wave}} \sim 1 \text{ kHz}\)

Connection length: \(10 \text{ m} < L < 1000 \text{ m}\)
\(\tau_p \) (parallel loss) \(> 1 \text{ ms}\)

Probe arrays in end plates provide vertical and full radial profiles

Isolated end plates may apply radial electric fields: \(V_p \leq \pm 100 \text{ Volts}\)
Density Profiles for various Gases

- Helimak
- Density

Drift-wave region

Magnetic Probe Location

Gases: He, Ne, Ar, Xe

Magnetic Probe Location

Graph showing density profiles for different gases (He, Ne, Ar, Xe) with a peak in the drift-wave region.
Typical Temperature and Floating Potential Profiles

[Graph showing temperature profiles for different elements: He, Xe, Ar, Ne, with corresponding floating potential profiles.]
Radial Profiles of Fractional Fluctuation Amplitude
Cross-Phase between probes with various $\Delta z$

$\Delta z = 2 \text{ cm}$

$\Delta z = 10 \text{ cm}$

Consistent with drift-wave velocity
Magnetic Fluctuations

Helimak
Magnetic Fluctuations

- Small: $\tilde{B} < 10 \, \mu T; \quad \tilde{B}/B < 10^{-4}$
- Highly non-Gaussian -- intermittent
- Correlated with drift wave $\tilde{n}$
\( \tilde{B} \) vs. \( \beta \)
$n=0$

B not Gaussian

dB/dt

PDF (log)
Br-n Cross-correlation

$\Delta R = 0.15$

$\Delta R = 0$

$\Delta R = -0.3$
Radial Cross-correlations

- $\Delta R$ vs. $n-n$ and $n-\text{Br}$

- Peak at $n-n$ at approximately $0.6$ units
- Flat line for $n-\text{Br}$ at around $0.2$ units
Br-n Coherency

ΔR = 0
ΔR = 0.15
ΔR = -0.1
Magnetic Structure and Scalings
$B_r - B_z$ Cross-Correlation

$dB/dt$

$B$

$t$

Helimak
Callen, PRL 39, 1540
Conclusions

- Drift waves have associated magnetic fluctuations
- The $j_{||}$ seems “more turbulent” than $n$
- Magnetic fluctuations open a new “window” on drift-wave dynamics