Characteristics of geodesic acoustic mode zonal flow and ambient turbulence at the edge of the HL-2A tokamak plasmas

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Outline

1. **Features of zonal flows**
2. **Structure of the three step langmuir probe (TSLP)**
3. **Experiment arrangements**
4. **Discharge parameters**
5. **Experiment results**
6. **Summary**

Zonal flow features

- Self-generated by turbulence
- Reducing turbulence level
- Two types of zonal flows: LFZF and GAM

  Poloidal and toroidal symmetries (*m=0, n=0*)

  Finite radial wave numbers
- GAM features

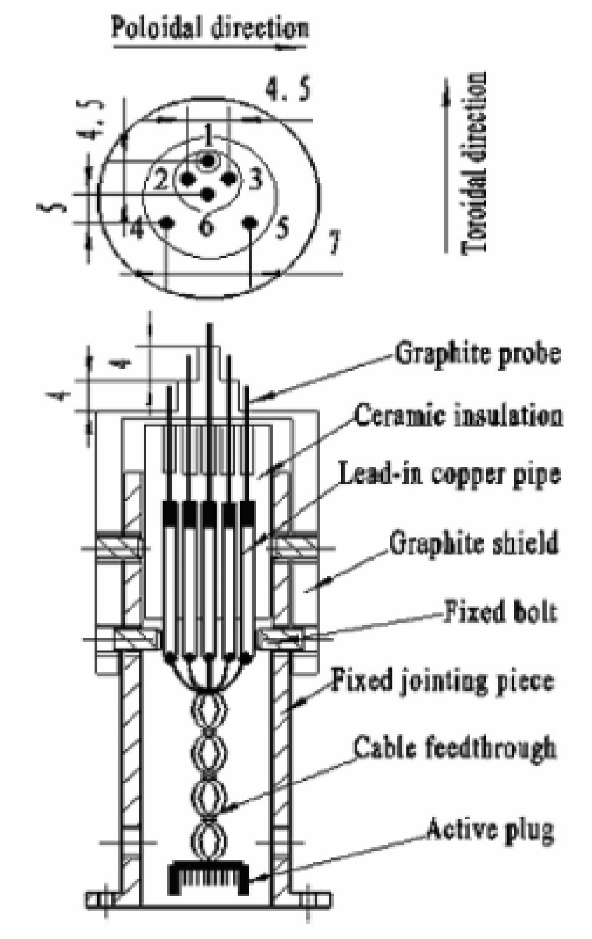
  Asymmetric density fluctuation (*m=1*)

  Frequency : $f_{GAM}^{th} = C_s / 2\pi R$

  Collisionless damping: $\gamma_q \sim \omega \exp(-\alpha q^2)$

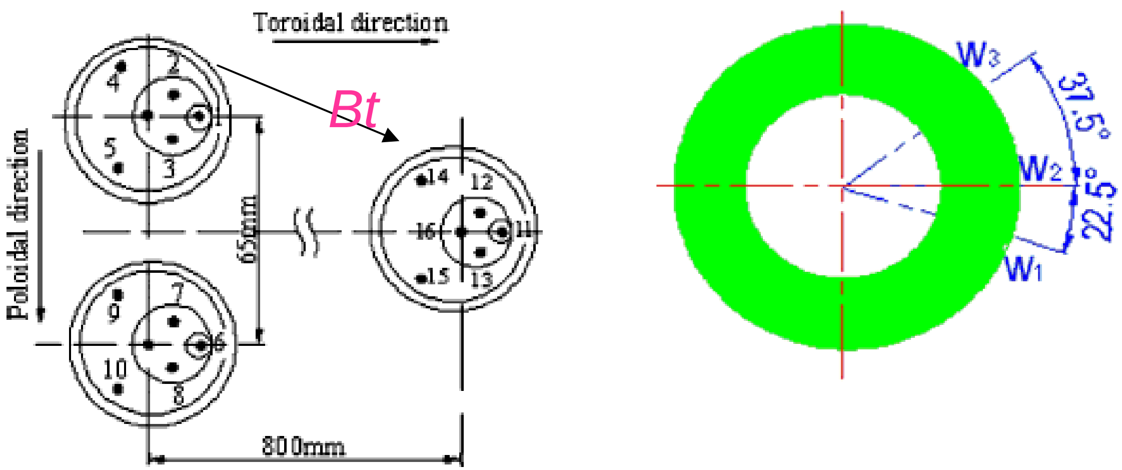
  Collisional damping: $\gamma_c \sim 4\nu_{ii} / 7$

Structure of TSLP



- Three step langmuir probe array (TSLP)

Experiment arrangements

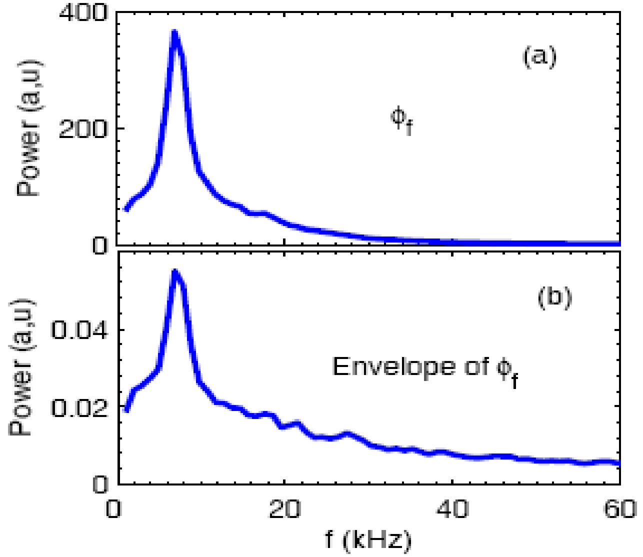


- TSLPs are distributed toroidally and polodially. Two of them form poloidal ZF probe set (W1).
- The third array of *6* probes is located *800mm* away in toroidal direction (W2).
- There is a fourth array of fast movable *6* probes (W3).

Discharge Parameters

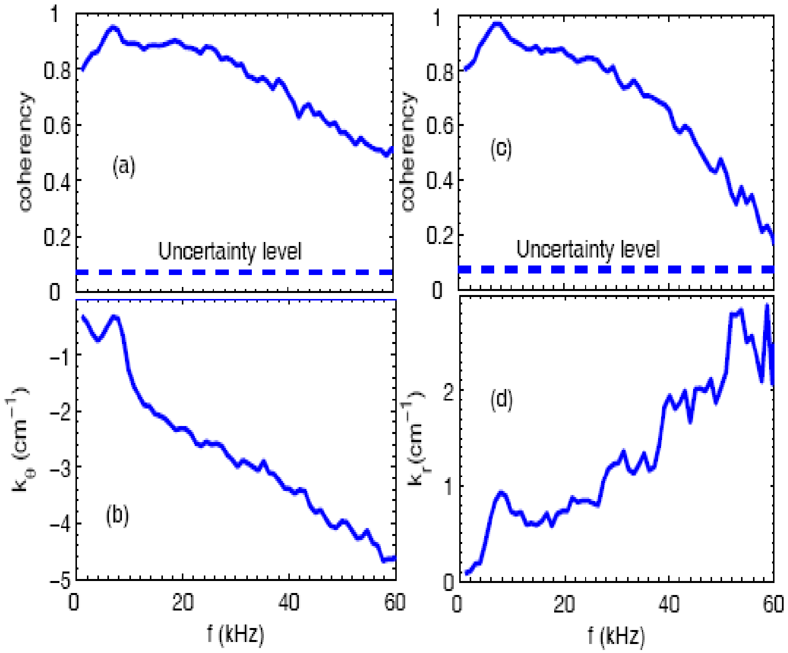
- Plasma current I_P=300kA
- Plasma density n_e=2x10^{13}cm^{3}
- Toroidal magnetic field B_t=2.2-2.4T
- Discharge duration t~2s
- LP position r/a=0.92
- Ion-ion collisional frequency ν_{ii}~1.5-3x10^{4}/s.

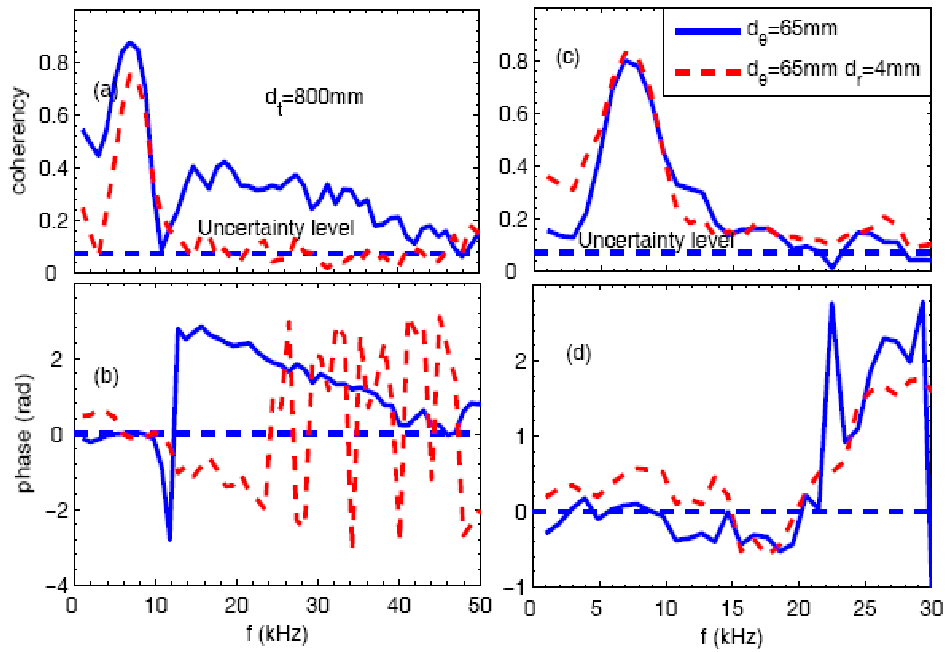
Floating potential fluctuation and envelope of fluctuation



•There are peaks at the GAM frequency in the auto-power spectra of floating potential fluctuation and HFC (200-450kHz) envelope. The lifetime of the GAM is estimated as *200-300μs* from the widths of *3-5kHz* of the peaks.

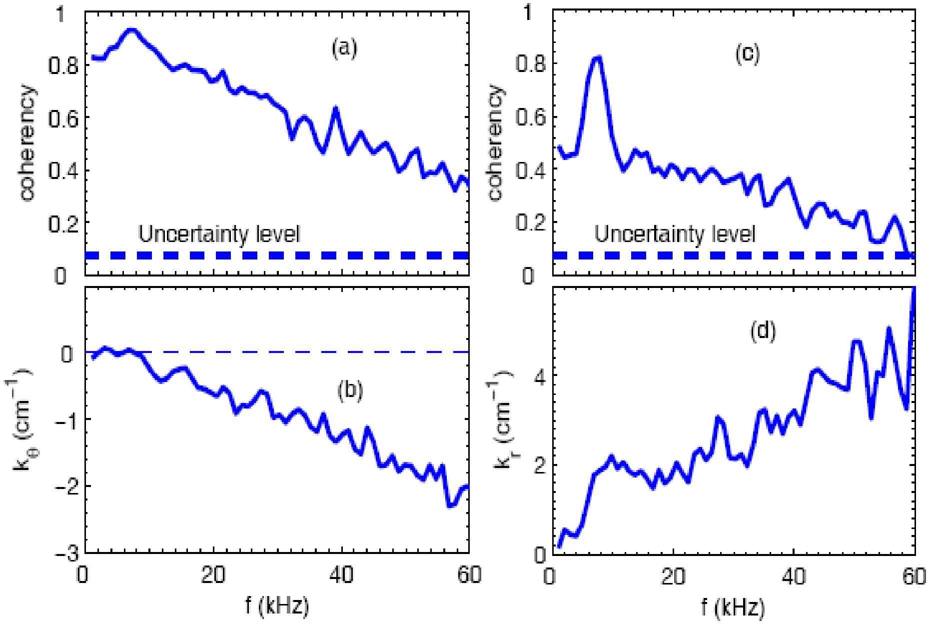
GAM features

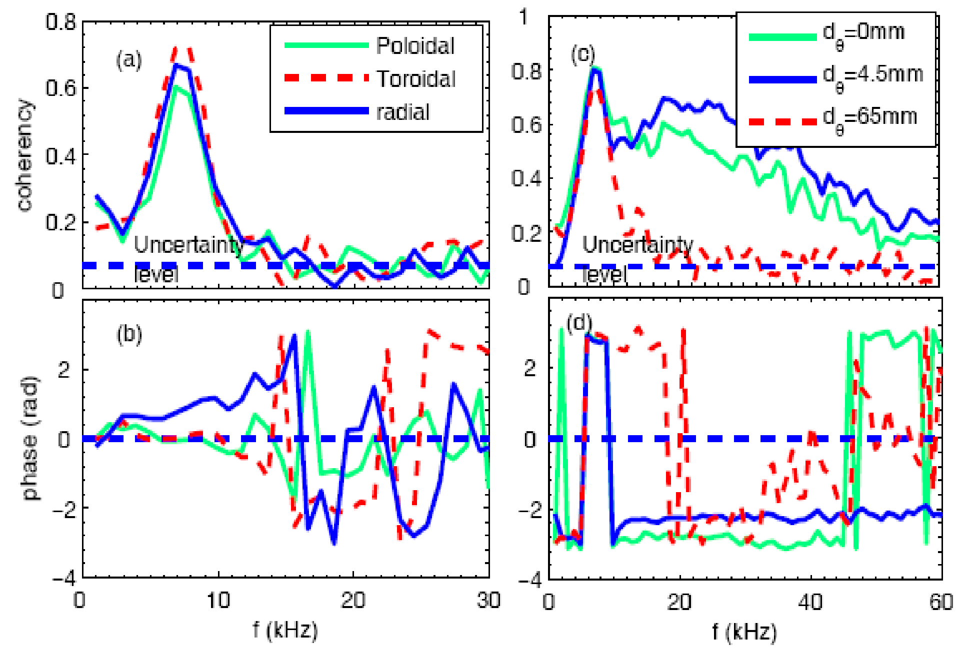




- GAMs have poloidal and toroidal symmetries (m=n=0), and radial localization (k_r=1.3cm^{-1}).

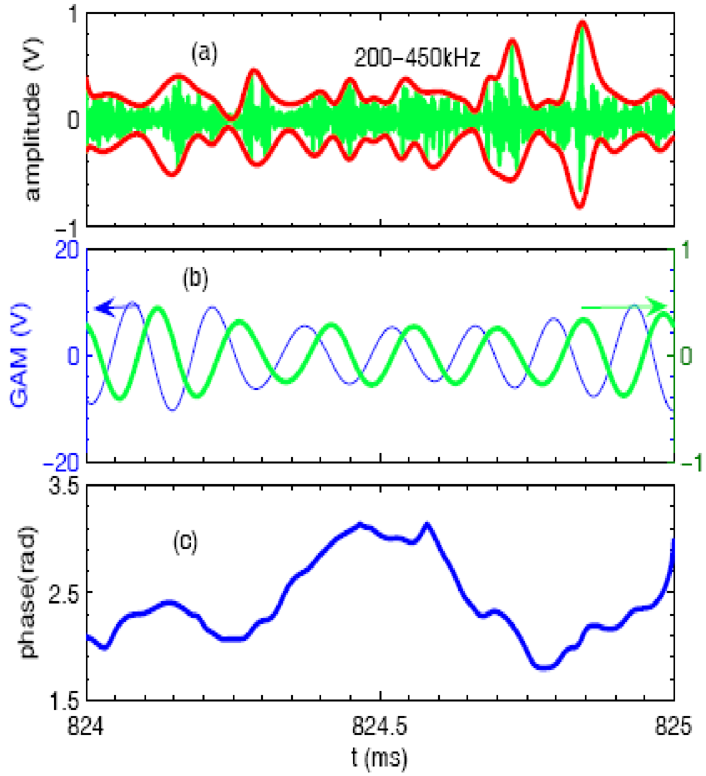
Coherent envelope symmetries

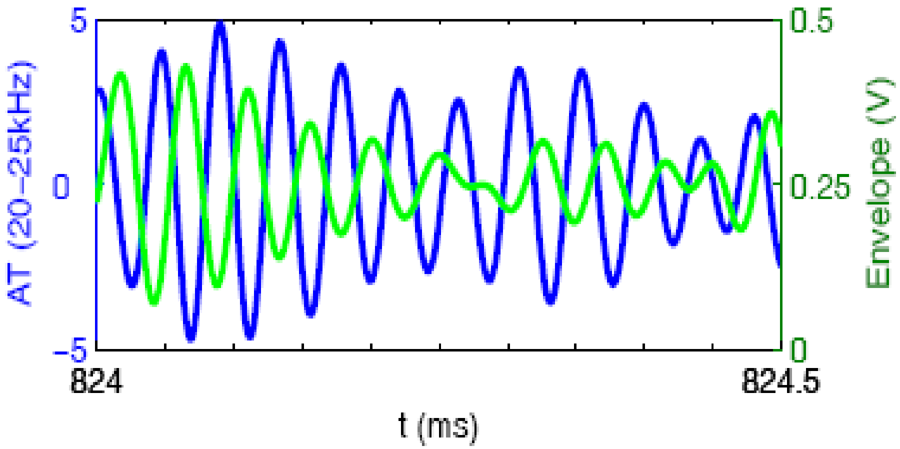




- The spatial structures of the components of GAM and LFC in the envelopes are similar to that of the GAMs and LFCs of the AT, respectively. The components of GAM and LFC in the envelopes have high correlation with GAM and the LFC of the AT, respectively, with phase shifts colse to π in both cases.

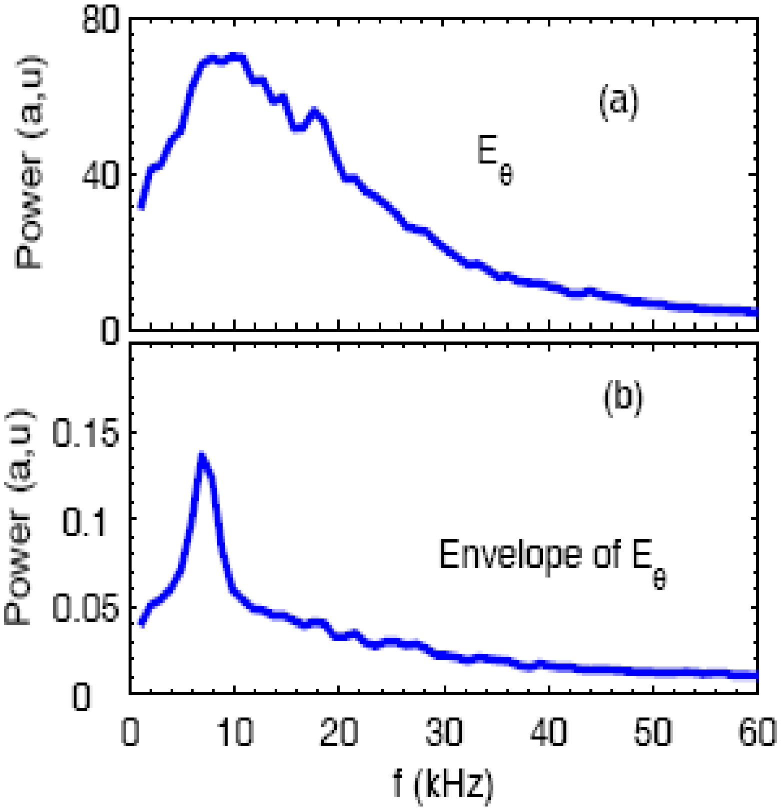
Correlation between coherent mode and envelope





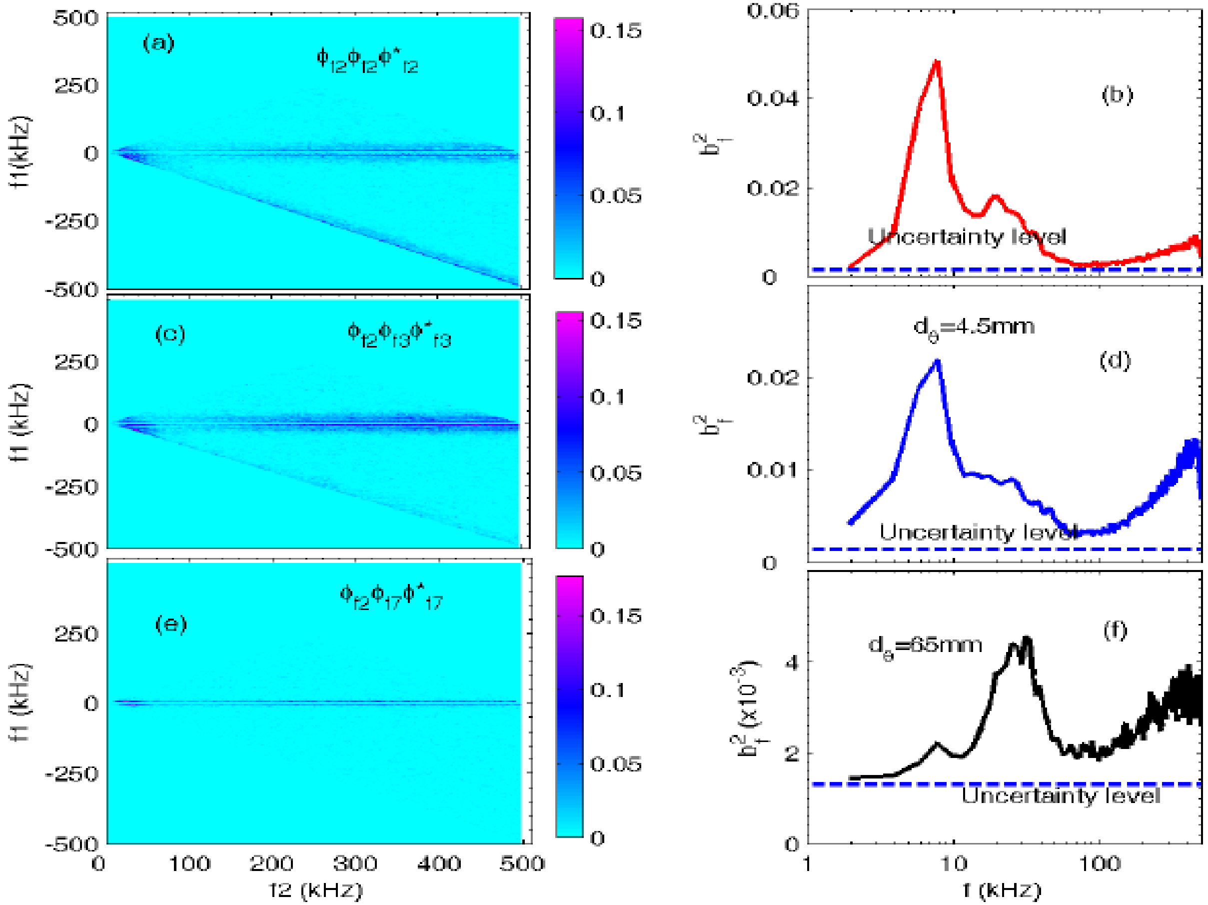
- The components of GAM and LFC in the envelope correlate with the GAM and the LFC of the AT, respectively, with phase shifts close to π in both cases.

Poloidal electric field fluctuation



- There are no clear peaks at the GAM frequency in the poloidal electric field fluctuation spectra, but a clear spectrum peak in the power spectra of the envelope.

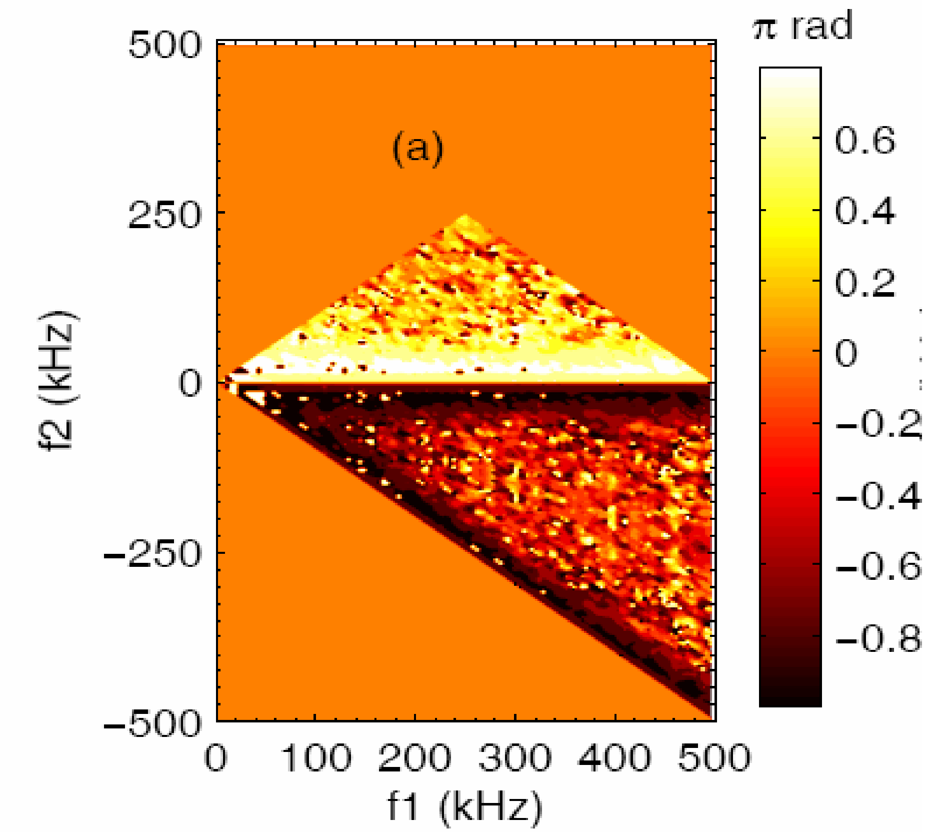
Nonlinear coupling



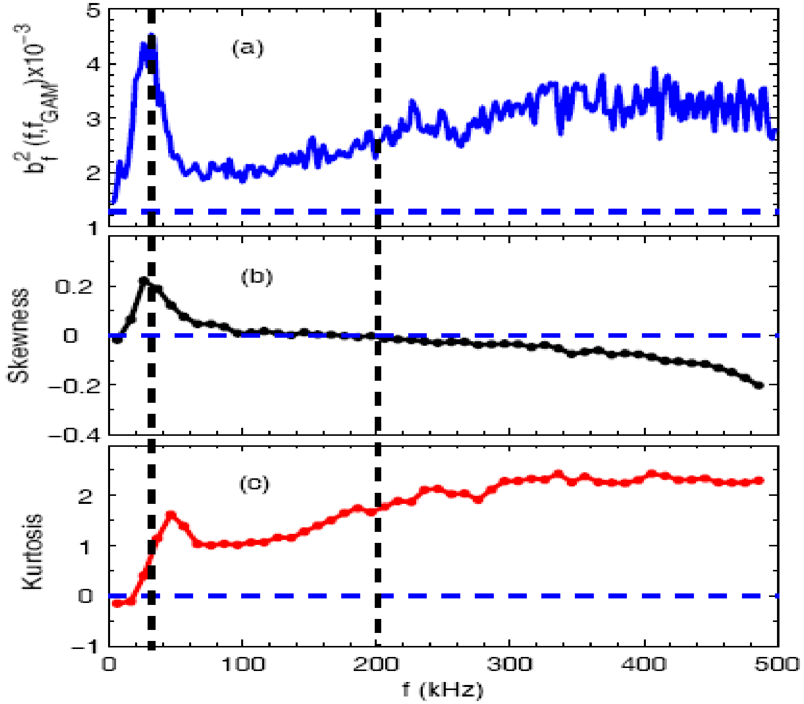
- **The GAMs were found to result mainly from three wave coupling of small scale fluctuations and act on the whole spectra of the ATs within the scale length of the former.**

Biphase

- Biphases are all close to π at the GAM frequency and the LFC frequency region of the AT.



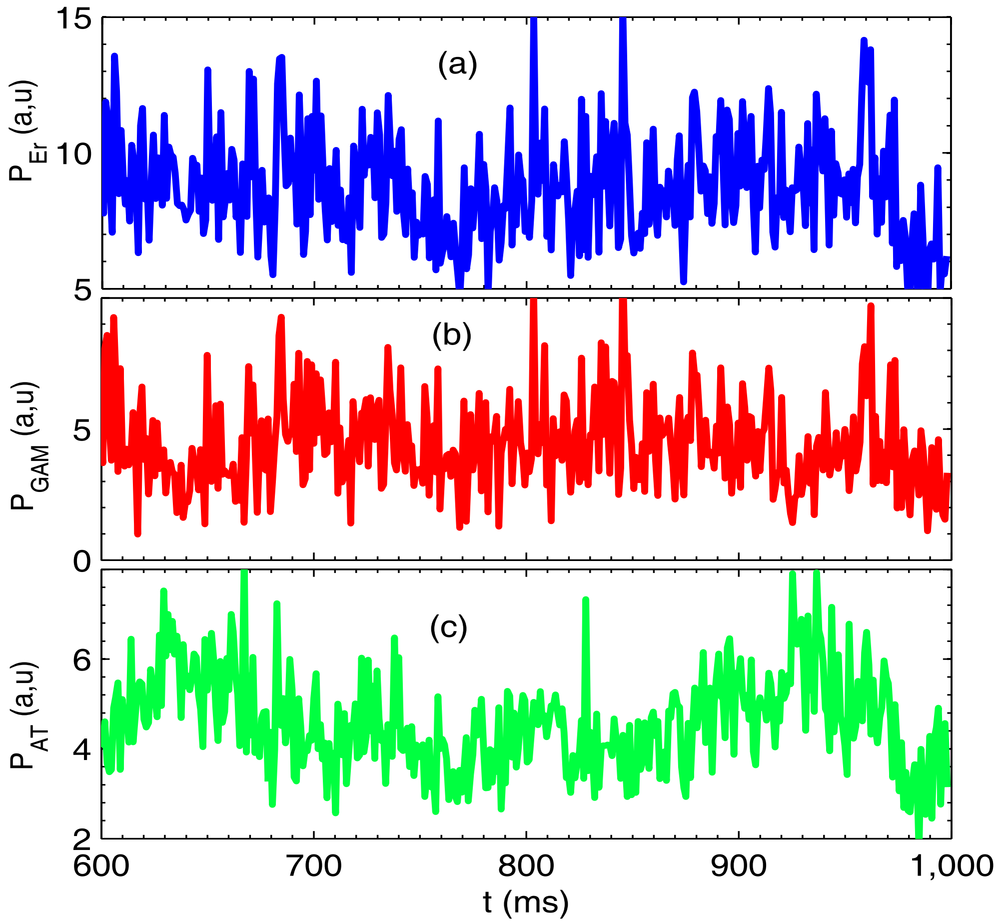
Bicoherence links to skewness and kurtosis



- Kurtosis spectra have similar shape with that bicoherence spectra.

Reducing turbulent level

- GAM power increases when the AT power decreases.



Summary

1. Symmetric (*m~0,n~0*) potential fluctuations with the finite radial wave number were simultaneously measured in GAM frequency region (*7kHz*).
2. The GAM frequency components (GAMFCs) of the coherent envelopes are also shown to have poloidal and toroidal symmetries, and similar radial scales as the GAM does.
3. The components of GAM and LFC in the envelope have high correlation with the GAM and the LFC of the AT, respectively, with phase shifts between $\pi/2$ to π in both cases.
4. The structures of the components of LFC in the envelopes are identified to be similar to that of the LFCs of the AT.
5. The GAMs were found to result mainly from three wave coupling of small scale fluctuations and act on the whole spectra of the ATs within the scale length of the former.
6. The GAM may reduce the turbulent fluctuation level.

Thank you for your attention