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The study of GAM properties in the T-10 tokamak

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Geodesic acoustic modes (GAM) were investigated on the T-10 tokamak using Heavy Ion Beam Probe (HIBP) and Correlation Reflectometry (CR) diagnostics [1]. Regimes with Ohmic heating and with on- and off-axis ECRH were studied (B = 2.2–2.5T, I_p = 180-330kA, $n_e = (1.3 - 2.5)\times10^{19}$ m^{-3}). Experimental layout is as follows: one CR antenna is located at the same cross section as HIBP at the Low Field Side, another one has a toroidal shift of one quarter of the torus, it is located at the High Field Side. Multipin movable and fixed limiter Langmuir probes (MLP) are located at the CR diagnostic cross-section. This layout aims at the future study of the toroidal and poloidal mode structure of GAM. The paper is dedicated to the first result of the correlation measurements of the HIBP, CR and MLP diagnostics.

HIBP is a powerful diagnostics to study GAM [2]. It is able to get simultaneously the oscillatory components for plasma electric potential and density from the total secondary beam current, I_{tot}, if the beam attenuation does not affect the signal (path integral effect). This is the case of low density, which was studied here. It was shown the GAM are more pronounced in the plasma potential rather than density. Figure 1 shows the potential and density power spectra, obtained by HIBP at the same time. It is clearly seen that GAM peak is dominant in the potential spectra while MHD m=2 peak dominates the density spectra. It was shown that GAM might have a complex structure, not similar to conventional periodical oscillations with a single frequency. GAM has an intermittent character presenting the

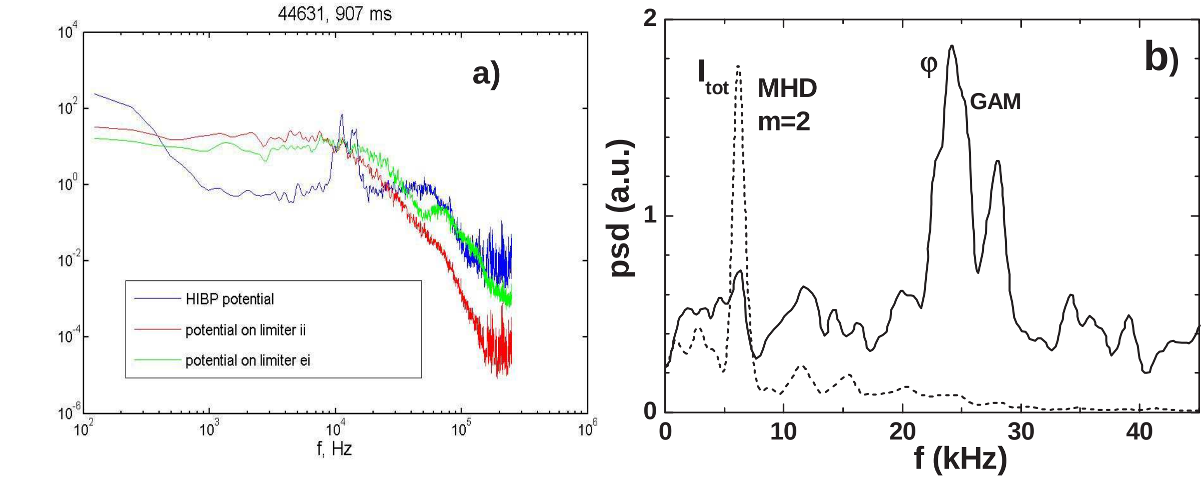

Fig 1. a) Potential power spectra in HIBP and MLP, clear double peak at 20 kHz characterize GAM, while no pronounced GAM peak in MPL spectra, b) Potential and I_{tot} (n_e) spectra by HIBP.

stochastic sequence of the wave packages. These complex properties (intermittent and double-frequency) of GAM can be clearly seen in temporal wavelet spectrum of potential fluctuations, see Fig. 2a. For the observed T-10 conditions the "lifetime" of the wavelet-package lies in a range of 0.5 - 2 ms.

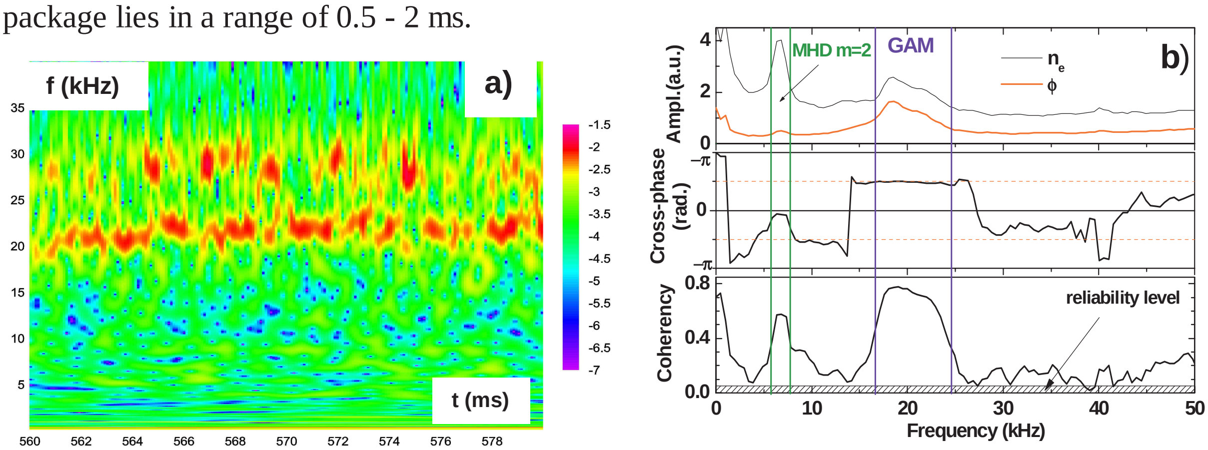

Fig. 2. a) Wavelet spectrogram for HIBP potential. ECR heated plasma. b) Local potential-density correlation. HIBP shows that GAM oscillations are more pronounced on the potential than on the density. In contrast, the amplitude of 7 kHz MHD m=2 oscillations is larger on the density and much smaller on the potential.

GAM are more pronounced in ECRH plasmas, where the typical frequencies of the wave packages are observed in a narrow interval from 22-27 kHz at the outer one third of the plasma column. The clear correlations between potential and density are seen in the HIBP. The phase shift is $\pi/2$ for GAM. In contrast, for MHD *m*=2 peak, the phase shift is zero.

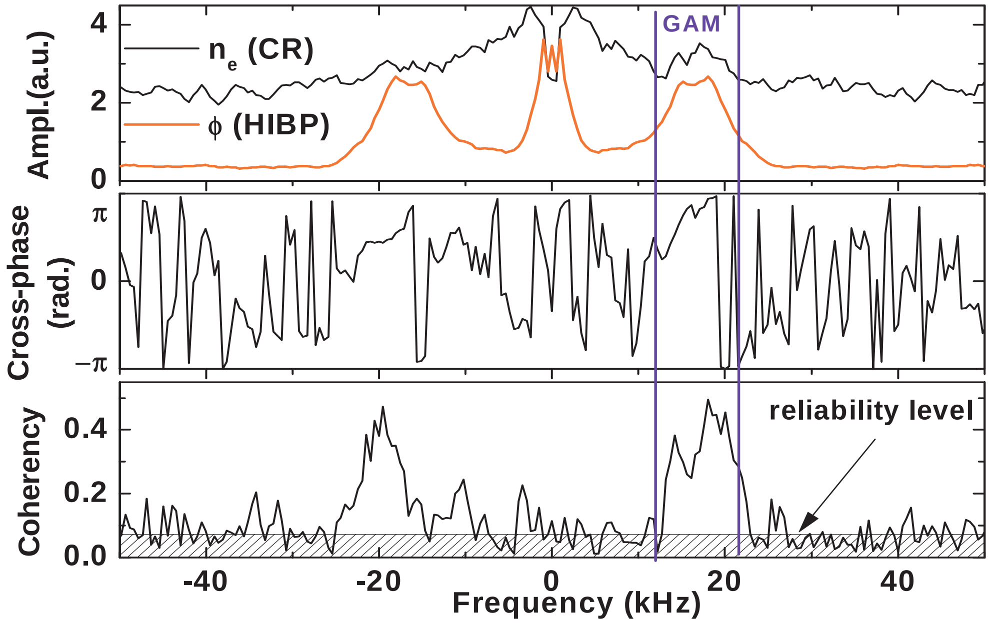

Fig 3. Long-distance potential-density correlations. HIBP versus CR.

Fourier correlation analysis reliably shows a clear correlation between HIBP potential and CR density at the GAM oscillations frequency, see Fig. 3. The phase shift is a topic for further more accurate analysis. This observation suggests a global character of the GAM.

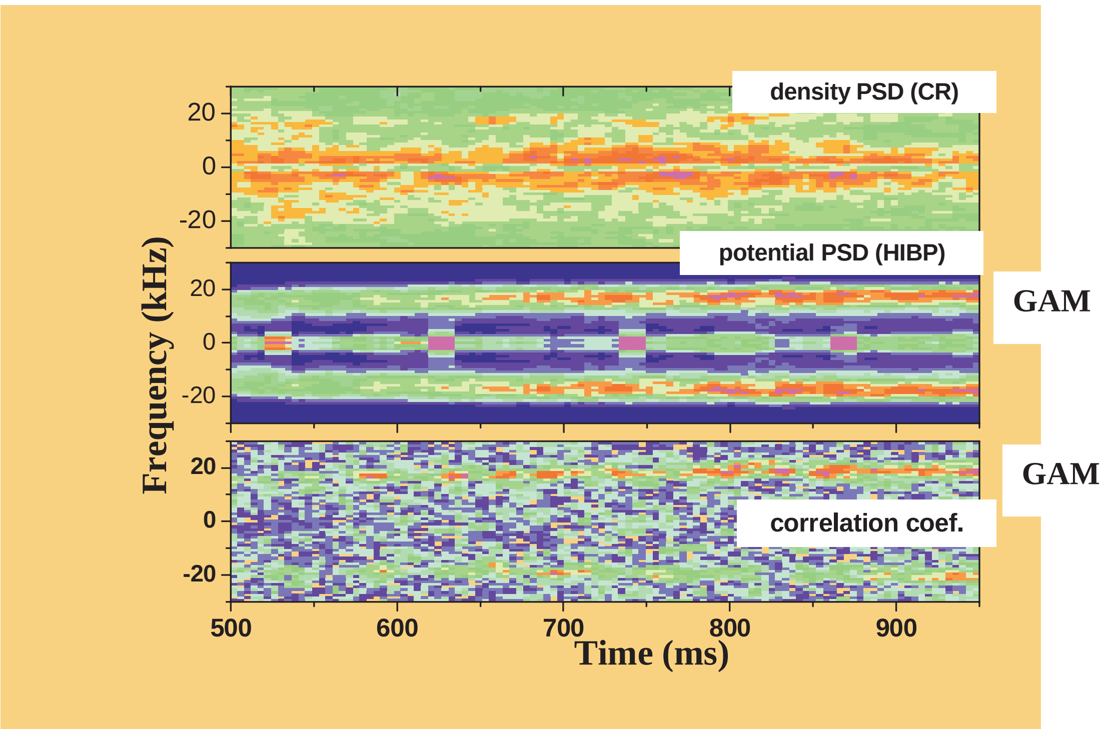

Fig 4. Time evolution of long-distance potential-density correlations. HIBP versus CR.

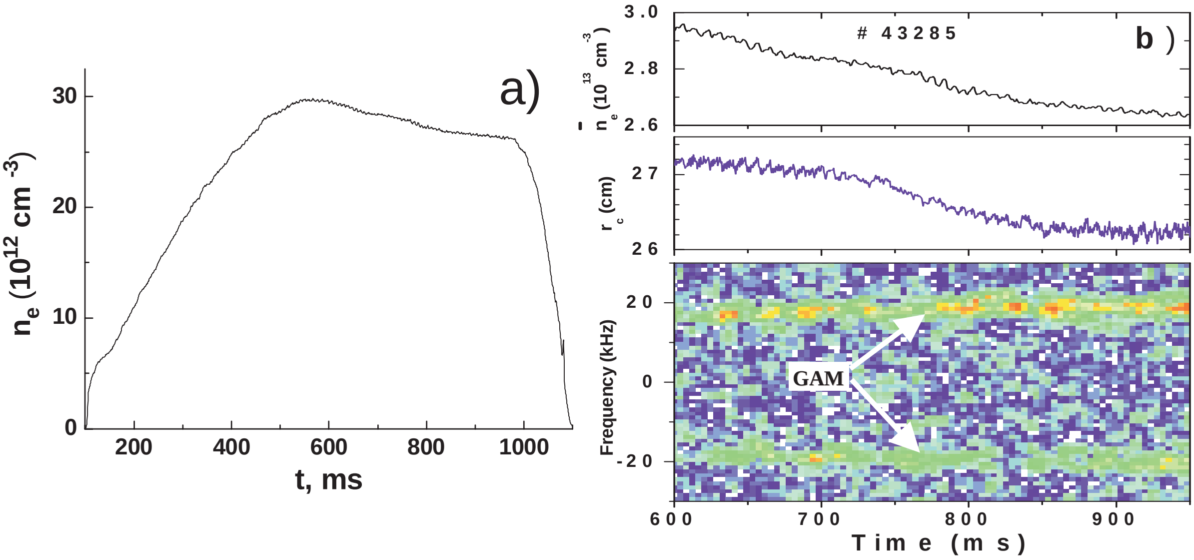

Fig. 5. Radial evolution of the long-distance potential-density correlations. a) Time trace of the density evolution in the OH discharge. b) Potential-density correlation for different radii for one shot. HIBP versus CR. Top box- line average density evolution. Middle box – corresponding CR observation radius. Bottom box - potential-density correlation coefficient. HIBP radial position is r = 25±0.5 cm.

To study the radial range of the long-distance correlations, the following experiment was performed: HIBP was located at the fixed position, while CR observation radius (reflection layer) varied during a shot with some decay of the local density. Fig. 4 shows the reliable existence of the correlation at the GAM frequency during the whole shot. Fig. 5 shows that the correlation coefficient remains almost unchanged with around 1 cm radial variation of CR, while HIBP position was 1 cm shifted. This observation means the radial correlation length for GAM is higher than 2 cm. This agrees with our earlier CR estimation of k_r = 3-5 cm [3].

Summary

A GAM correlation study was performed by HIBP and CR for the first time. It shows: GAM are mainly manifested in the plasma potential, and are not much pronounced on the plasma density fluctuations; GAM have an intermittent character in amplitude and frequency, a potential density phase shift of $\pi/2$, and feature long-distance correlations, suggesting that GAM are global modes with radial correlation length in the range of a few cm.

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