Laser Scattering Measurement of the Electron Density Fluctuations in CHS

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1. Backgrounds and Purposes

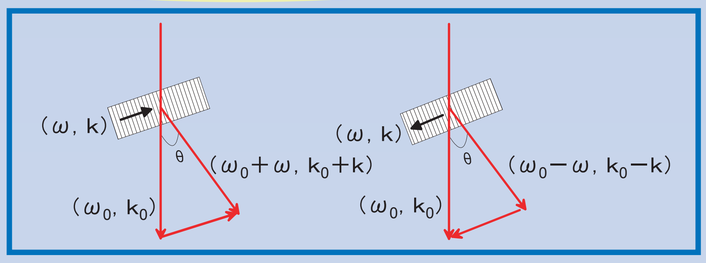
In magnetic confinement fusion devices, It is considered that fluctuations cause anomalous transport and degrade plasma confinement.

→ The electron density fluctuations measurement by the electromagnetic wave scattering method using HCN laser CHS(Compact Helical System).

- Decrease of the fuctuations in the case of Edge transport barrier(ETB)formation → Examination of the timing and the time scale of decrease of fluctuations in the case of ETB formation
- Appearance of the spectrum which have harmonic components up to the fifth and that the frequency becomes high as the heating power increases. → Analysis of the dependence of the frequency of the harmonic components on plasma parameters

2. Methods and Principle

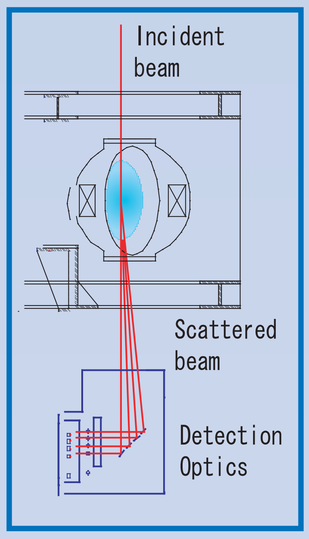
Principle of Scattering Method



Bragg scattered light by the density fluctuations

angle: $\theta_s = 2\sin^{-1}\{k/2k_0\}$ ← Scattering angle corresponds to fluctuation wave number

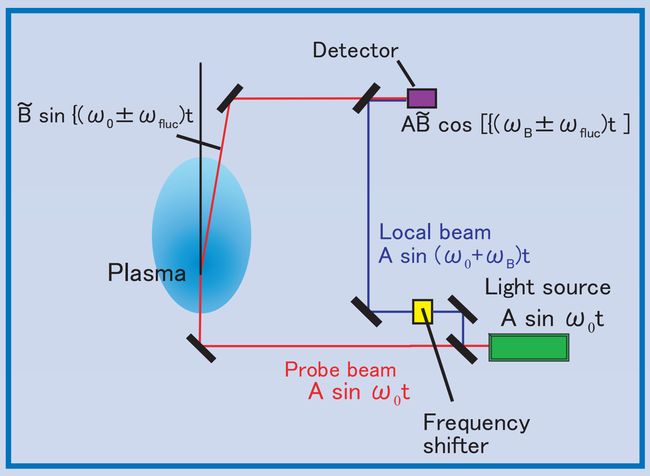
frequency: $\omega_s = \omega_0 \pm \omega$ ← As $\pm\omega$ can be known by heterodyne technique, the propagation direction of fluctuations can be identified



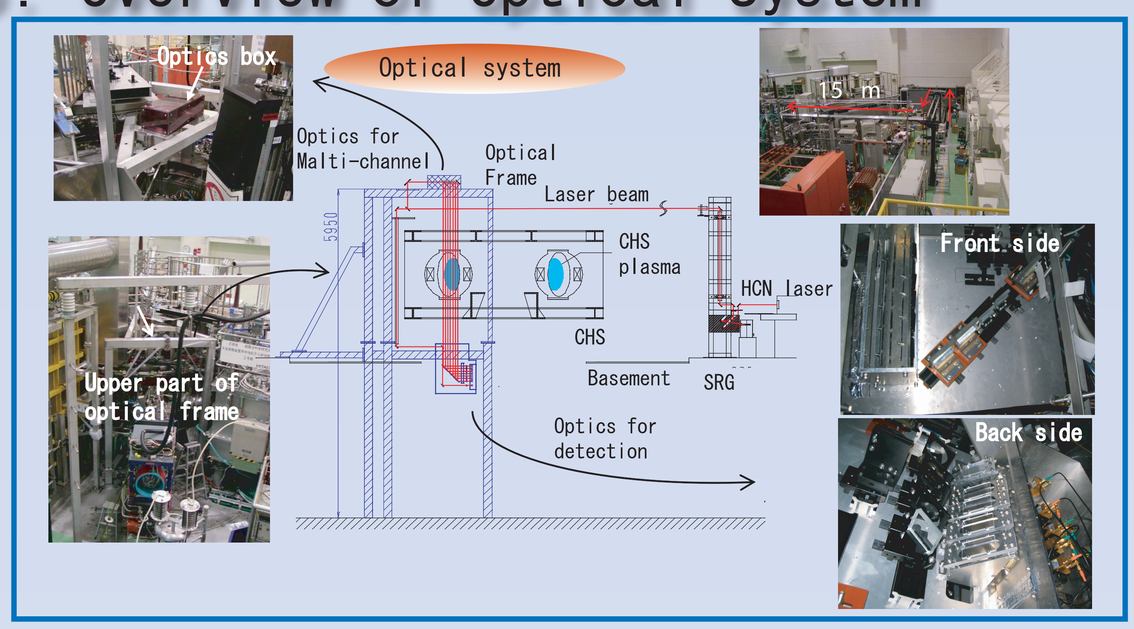
Heterodyne Measurement

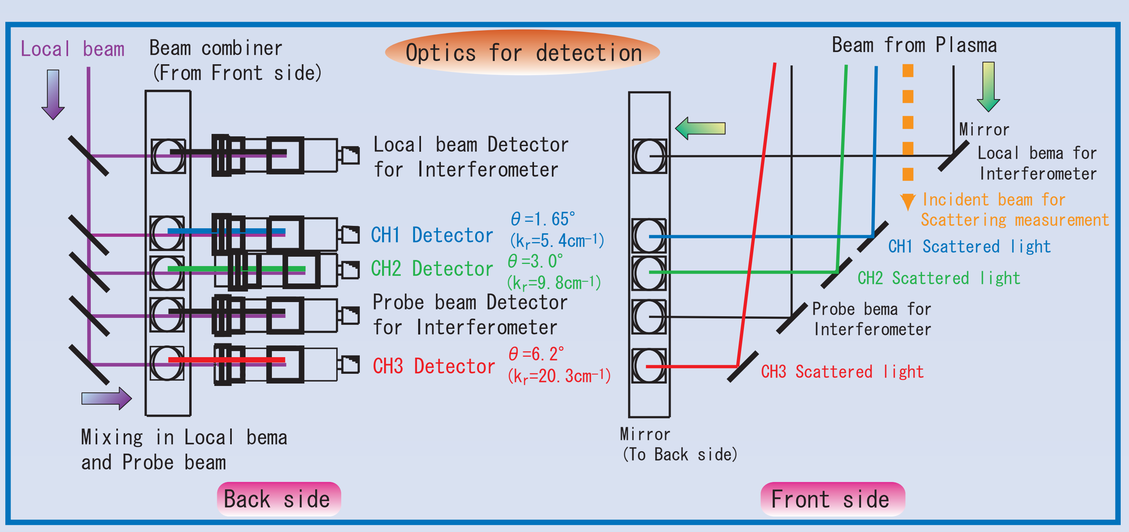
$$\left[A\sin\{(\omega_0+\omega_B)t\}+\tilde{B}\sin\{(\omega_0\pm\omega_{fluc})t\}\right]$$
$$\cong A\tilde{B}\cos\{(\omega_B\pm\omega_{fluc})t\}+\text{other terms}$$

Since the beat frequency ω_B is baseline, plus and minus of the frequency of fluctuation ω_{fluc} can be measured



3. Overview of Optical System

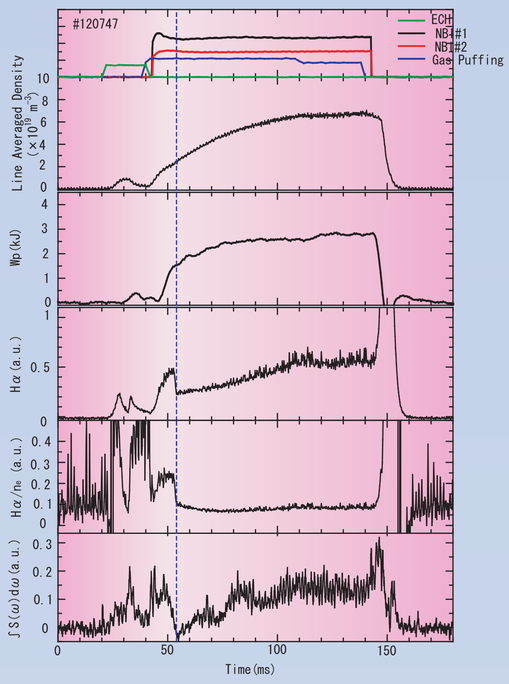




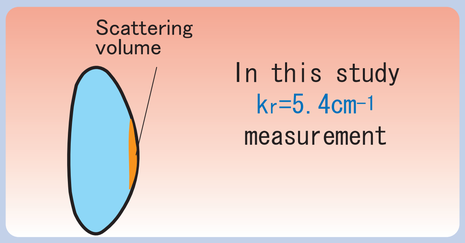
- Optical system which used part of interferometer
- It uses the HCN laser which suited plasma prameters of CHS.(Wavelength : 337μm)
- High beat frequency of 1 MHz is achived by using SRG (Super Rotating Grating).This enable us to measure fluctuations up to 1 MHz.
- It is possible to acquire fluctuation spectra with 3 wave numbers simultaneously because it detects scattered lights at 3 angles simultaneously.

4. Results

Fluctuations at ETB Formation

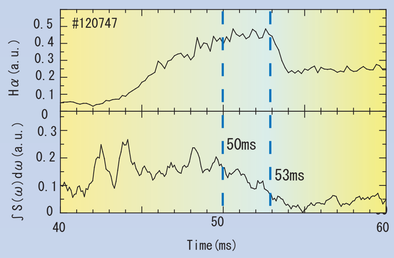


TIme evolutions of operation and plasma parameters



In this study
k_r=5.4cm^{-1}
measurement

- An edge taransport barrier(ETB), which can improve particle transport in the edge region, has been observed in CHS.
- In the case of ETB formation, Hα emission signal, which roughly indicates infomation on the particle flux into the plasma, decreases spontaneously.
- Fluctuations were suppressed at ETB formation.



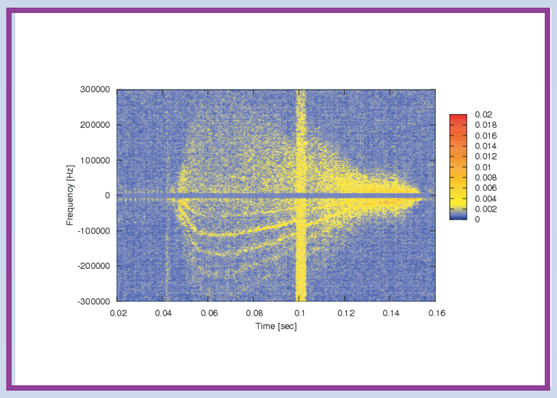
Time evolution of Hα emission signal and a spectrum integration in the frequency across ETB formation

The decrease of the fluctuations is earlier by about 3ms than Hα drop.

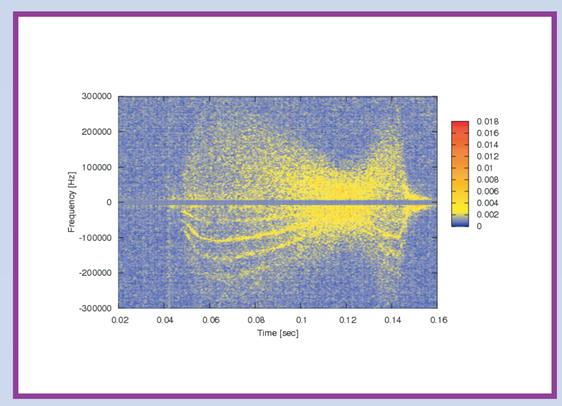
Analysis of Harmonic Components

Sharp fluctuation peaks, which have harmonic components up to the fifth, were observed

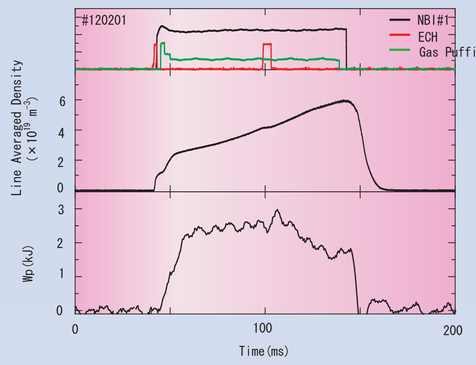
Characteristic
- The fluctuations propagate only in the outward direction.
- The amplitude of the second component is always the largest among harmonic components.



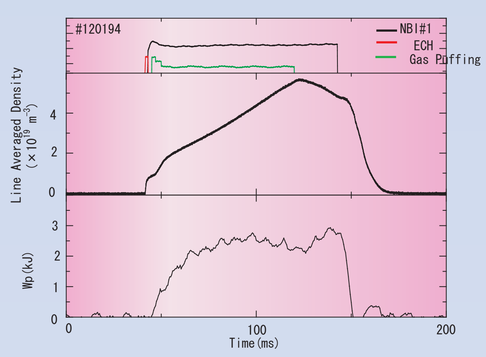
Time evolution of fluctuation spectra #120201



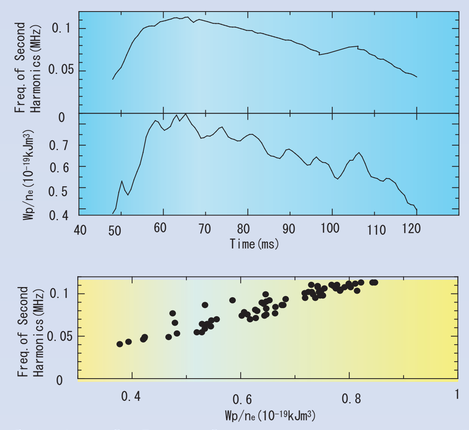
Time evolution of fluctuation spectra #120194



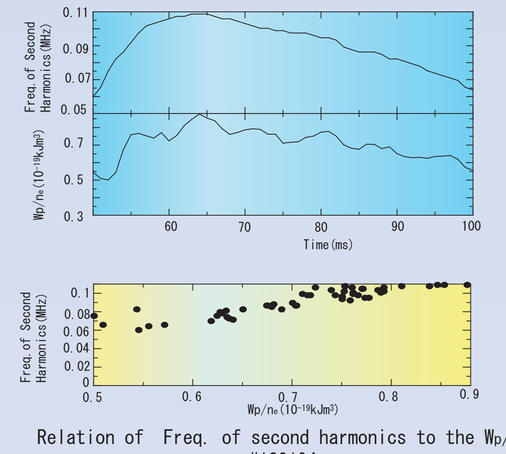
TIme evolutions of operation and plasma parameters #120201



TIme evolutions of operation and plasma parameters #120201



Relation of Freq. of second harmonics to the Wp/ne #120201



Relation of Freq. of second harmonics to the Wp/ne #120194

The frequency of harmonic components correlates with average temperature defined as the plasma stored energy divided by line average density.
The frequency rised with Wp/ne

5. Summary

Examination of the timing and the time scale of decrease of fluctuations in the case of ETB formation
↓
The decrease of the fluctuations is earlier by about 3ms than Hα drop.

Analysis of the dependence of the frequency of the harmonic components on plasma
↓
The frequency of harmonic components correlates with average temperature defined as the plasma stored energy divided by line average density.
The frequency rised with Wp/ne