§15. Estimation of Effective Mass by Density Fluctuation Frequencies

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In future isotope plasma experiments and also burning plasma reactor, the fueling mass ratio is one of the important parameter for the stable operation. Currently several diagnostics are proposed for this aim, such as CXRS, neutron spectrometer, etc. Most of them is measured directly each element or its reaction. On the other hand, some plasma phenomena, (e.g. Larmor radius, cyclotron motion, density fluctuation, etc.) are affected by the atomic mass. When we measure such kind of phenomena, the corresponding mass can be estimated.

In this time, we try to estimate by the combined analysis of two type of density fluctuation frequency. One is the toroidal Alfvén eigenmode (TAE) and another one is geodesic acoustic mode (GAM). Of course one phenomenon can lead the single value of mass. However, since two estimated values must be single result, it leads to be the reduction of the estimation error.

The frequency of TAE is expressed by,

$$f_{TAE} = \frac{\upsilon_A}{4\pi q_{TAE} R} \quad . \tag{1}$$

Here, v_A is the Alfvén velocity, q_{TAE} (=1/ ι) is the safety factor, R is the major radius. And GAM frequency is described by,

$$. f_{GAM} = \frac{\sqrt{2}}{2\pi R} C_s \tag{2}$$

Here, C_s is the ion sound speed. Both frequencies have the -1/2 power dependence of mass.

Experiment is carried out the condition that the magnetic axis is 3.5 m, the magnetic field strength is 0.9 T. The plasma is heated by un-balanced tangential NBI and the plasma current is increased gradually. It makes the profile of rotational transform ι is changed and the reversed shear configuration is formatted in the core region [1]. The injected high energetic particles generate some MHD oscillations. One is the reversed shear Alfvén eigenmode (RSAE) which is a sort of TAE and its start frequency is expressed by TAE gap frequency. Also, such kind of phenomena generates GAM oscillation. Microwave reflectometer can be observed both fluctuations shown in Fig. 1. The frequency of RSAE moves up and down according to the ι value. It is the feature of this mode. At the time of 2.4 s the frequency is inversed and this frequency is used to estimate now. Frequency dependence of each mode on effective mass is shown in Fig. 2. Considering the condition that RSAE frequency of ~ 40 kHz and GAM frequency of ~18 kHz, it leads to better estimation and the estimated effective mass is around $1.7 n_H M_H$.

1) Toi, K. et al.: Physical Review Letters, **105**(2010) 145003

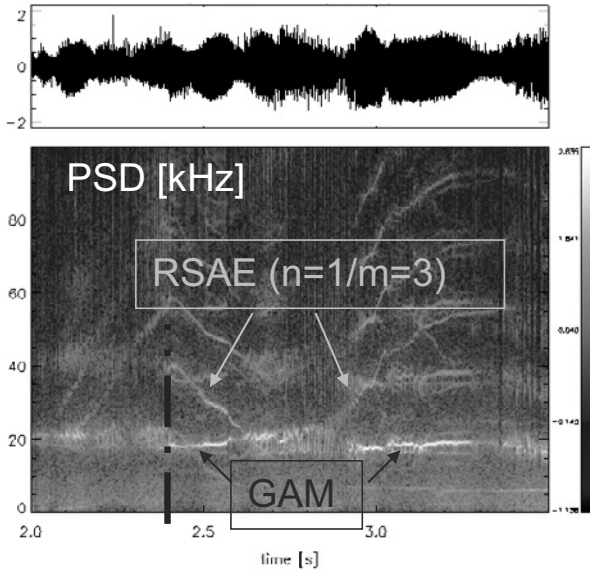

Fig. 1. Time traces of microwave reflectometer signal (top) and its frequency spectrogram (bottom). Frequency chirping RSAE mode and also GAM can be observed simultaneously.

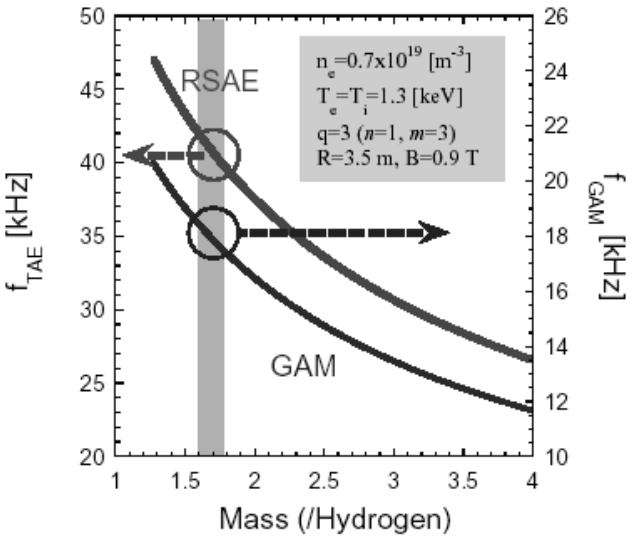

Fig. 2. Frequency dependence on the effective mass. Since start frequency of TAE is around 40 kHz and GAM frequency is 18 kHz, the effective mass is estimated about 1.7.