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Localized Electromagnetic Fluctuation during High Guide Field Magnetic Reconnection

高ガイド磁場リコネクションにおける局所的磁場揺動の発生

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Plasma merging is one of the potential scheme for center solenoid-free startup of high-beta spherical tokamak plasmas. By magnetic reconnection during plasma merging, magnetic energy is converted to plasma thermal or kinetic energy. To achieve high-beta equilibrium after merging, short reconnection time and highly-effective conversion from magnetic to thermal energy are required. Electromagnetic fluctuation has potential to enhance reconnection rate and provide efficient energy conversion. We observed a fluctuation of about 1MHz propagating inside a current sheet when reconnection electric field and effective resistivity was increasing. Detailed propagation property of the fluctuation was experimentally investigated

1. Introduction

Spherical tokamak (ST) plasma has an economical advantage because of its high normalized beta (β_N). Because of low aspect ratio of ST, there is a small space to locate a center solenoid(CS) coil which is used to rump up plasma current in tokamak devices.

Development of startup method of ST without CS coil is one of the important subjects and in the UTST device, plasma merging method is developed. Magnetic reconnection occurs during the plasma merging and magnetic energy is converted to thermal and kinetic energy. In order to make efficient use of reconnection during ST startup, short reconnection time and highly-efficient energy conversion are required. Fluctuations are often observed in association with magnetic reconnection and are considered to enhance reconnection rate and energy conversion efficiency. High frequency fluctuations with lower hybrid range of frequency was observed during non guide field reconnection in MRX[1] and low frequency, large amplitude fluctuation with ion cyclotron range of frequency was also observed during low guide field reconnection in TS-3[2]. Experiment in UTST reflects high guide field (B_t ~15B_p) reconnection in the tokamak configuration. In this paper, experimental results from detailed measurement of electromagnetic fluctuation in high guide field reconnection will be presented.

2. Experimental Setup

The UTST device has a cylindrical vacuum vessel, magnetic probe for measuring poloidal flux and TF, PF, EF and CS coils(fig.1). In the UTST device all the coils are located outside of vacuum vessel. The induced electric field by ramping down of 2 pairs of PF coil forms two STs at once. Typical poloidal(reconnecting) magnetic field is 15mT and toroidal(guide) field is about 230mT at r=35cm of the x-point location. To investigate the properties of electromagnetic fluctuation, we developed new magnetic probe and inserted in mid- plane (fig.2). Pickup coils of this probe has 15- turns and were located on each 1cm in the current sheet region.

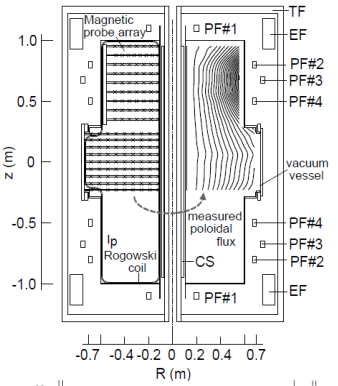

fig1.Closs-section view of UTST vacuum vessel and external coils to startup and merge two initial STs.

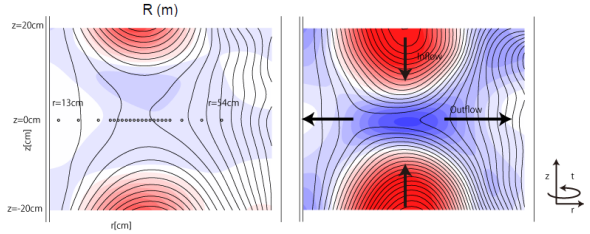

fig.2 Location of pickup coils in the vacuum vessel and schematic view of inflow and outflow during magnetic reconnection.

3. Experimental Result

Figure 3(a) shows a typical raw signal observed by a fluctuation pickup coil located near the x-point. In addition to the high frequency component, low frequency wave component is clearly observed. Spectrogram of the fluctuation shown in fig.-3(b) shows that the frequency of the low is similar to the cyclotron frequency of He^{+} in the current sheet.

Figure 4(a)(b) shows the spatiotemporal evolutions of the fluctuation. The low frequency component was observed to propagate from around the x-point to outflow region and disappeared near the edge of the current sheet.

Radial phase velocity of the fluctuation was about 40-80 km/s, which is close to the Alfvén velocity of 40-50 km/s calculated from upstream plasma parameters.

The fluctuation appeared at t=9590-9610 [μs], when high reconnection electric field was observed. (fig.4)

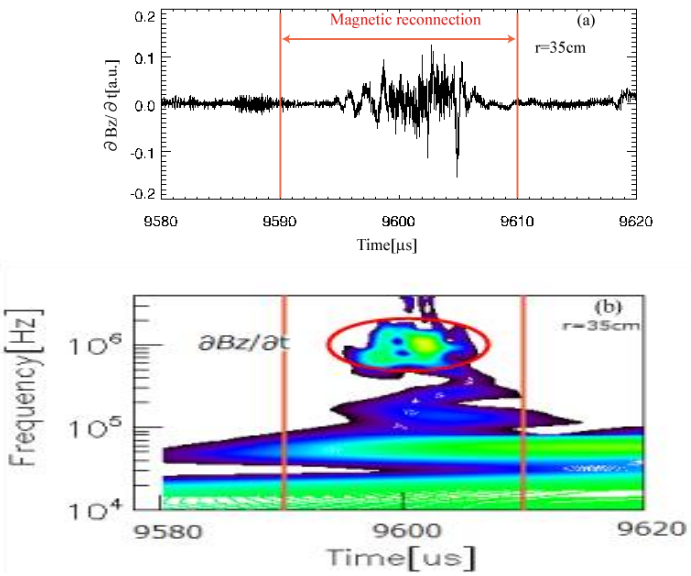

fig.3 Magnetic fluctuation profile ($\partial B_z/\partial t$) near the x point, r=35cm and power spectrum calculated by wavelet transform. It shows frequency component of 1MHz occurred.

6. Conclusion

During high guide field reconnection during ST merging startup, remarkable magnetic fluctuation activities were observed. The fluctuation included clear low frequency component with ion cyclotron frequency range and propagated radially with phase velocity close to the Alfvén velocity, which may relate to the intermittent feature of high guide field reconnection.

Acknowledgement

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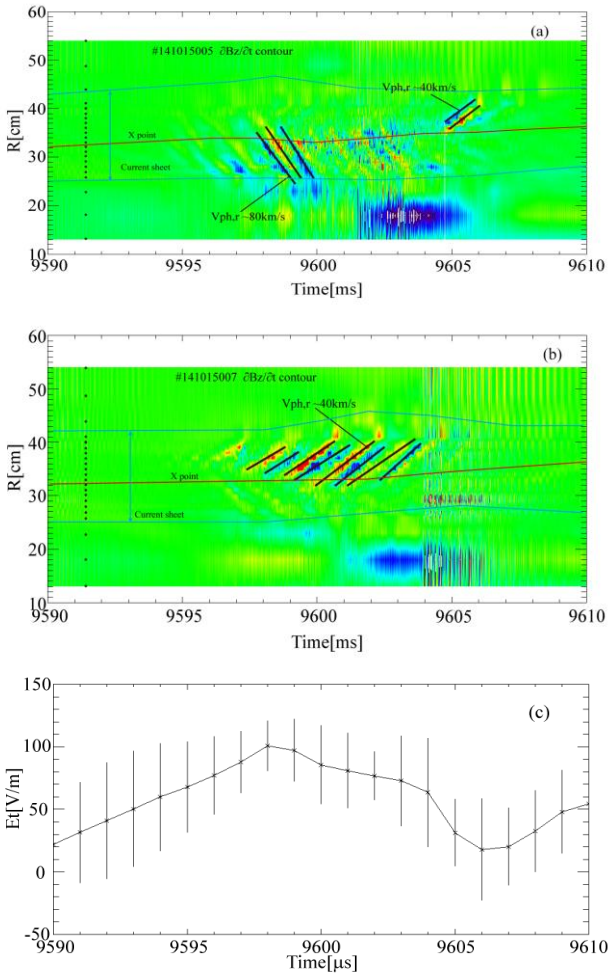

fig.4 Propagation of electromagnetic fluctuation toward outflow region, reconnection electric field and effective resistivity.

References

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