§21. Suppression of Spurious Mode Radiation in Mega-watt 77 GHz Gyrotron for Application to Collective Thomson Scattering in Measurements in LHD

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Recent development of high-power radiation sources, like mega-watt class gyrotrons and relevant transmission/antenna system, made it possible to conduct collective Thomson scattering (CTS) measurement on fusion plasmas[1]. For measuring bulk and tail ion velocity distribution functions in high density and high temperature plasmas in the Large Helical Device (LHD), high frequency sub terahertz gyrotron has been developed[2]. In parallel, the CTS diagnostic has been tried utilizing the existing electron cyclotron resonance heating (ECRH) system with high power mega-watt gyrotrons at the frequency of 77 GHz as a benchmark for clarifying the issues and developing the method[3].

In order to improve the signal to noise ratio for the CTS measurement, the power of the CTS probe beam is modulated to subtract the background electron cyclotron emission (ECE) and system noise from received signals. Fig. 1 shows (a) example of the RF signal of 77 GHz gyrotron and (b) the CTS signal. CTS signal was measured by a high sensitive heterodyne radiometer. The CTS receiver system details are noted in the reference [3]. During the turning on/off phase of the modulation, the spurious mode radiations which are superimposed on the measured CTS spectrum harm scattered signal although we must subtract the background ECE signal from the received signal accurately. Additionally, a spurious radiation signals saturates or overloads a specific channel even if it is a small

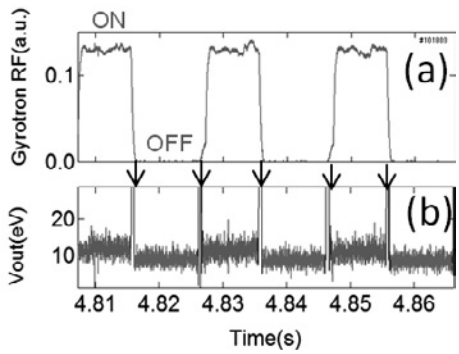

Fig. 1. Time evolution of (a) the RF signal of 77 GHz gyrotron, (b) CTS signals obtained in a high sensitivity heterodyne radiometer system [3]. Arrows indicate the spurious mode signals in Fig. 1 (b).

output power. And also they cause IF amplifiers for gain compression. Received signal couldn't be detected correctly during gain compression. Therefore, it is essential to suppress or reduce the spurious radiation.

Based on the results of the mode competition calculation[4], the 77 GHz gyrotron have been operated at the higher magnetic field strength at the cavity B_c than that of the normal operation where the B_c and Anode voltage of the gyrotron V_a are set to maximize the output power of the main $TE_{18,6}$ mode. The time evolutions of the frequency spectrum are measured at nominal and higher B_c. Fig. 2 shows results of frequency measurement in an operation at normal B_c = 2.99 T and higher B_c = 3.06 T which are setting value containing $\pm$1 % error. In the both measurements, cathode voltage 80 kV, anode voltage 45 kV, beam current 55 A and output modulated pulse width 60 ms are set the same. Although the spectrum peak corresponding to the main output mode signal can be found over the almost full width of modulated pulse as shown in Fig. 2 (a), that of spurious mode signal appears at the rising and falling phase of the V_a as shown in Fig. 2 (b). In contrast, at the higher B_c operation, the spurious peak disappear transient phase of V_a as shown in Fig. 2 (d). It is considered that spurious mode ascribed to be $TE_{17,6}$ loses its oscillation condition due to the increase B_c. Other spurious mode peaks cannot be identified at the measurement in Fig. 2. On the other hand, the spurious radiation mode appears during modulation by decreasing B_c compare with normal B_c operation.

The spurious radiation at the 74.7 GHz is suppressed by increasing B_c. Although the spurious mode is suppressed, the main mode power is decreased down to about 300 kW which is one third of the main mode power under the normal B_c operation. Optimizing operation conditions under which the main mode power is higher with the spurious modes suppressed are left for the future work.

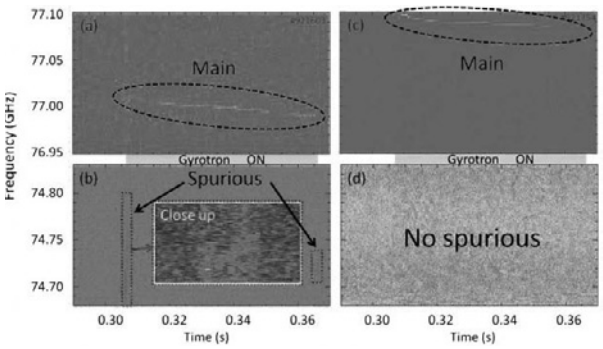

Fig. 2. Time evolution of spectrogram around main mode and spurious mode of the 77 GHz gyrotron.

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