22P124-P

Electron Density and Fluctuation Measurements by Using a Frequency Multiplied Microwave Interferometer System in the GAMMA 10 Anchor Cell

GAMMA10アンカー部における周波数逓倍器を用いたマイクロ波干渉計システムによる電子線密度・揺動計測

Junko Kohagura, Masayuki Yoshikawa, Yoriko Shima, Yuusuke Morikawa, Tomohiro Yamada, Daichi Akita, Mizuki Sakamoto, Yousuke Nakashima, Makoto Ichimura, Mafumi Hirata, Ryuya Ikezoe, Tsuyoshi Imai

小波蔵純子，吉川正志，嶋　頼子，森川裕亮，山田智博，秋田大地，坂本瑞樹，中嶋洋輔，市村　真，平田真史，池添竜也，今井剛

Plasma Research Center, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577, Japan
筑波大学プラズマ研究センター 〒305-8577　つくば市天王台1-1-1

A new interferometer is installed on the west anchor cell of GAMMA 10. In GAMMA 10, we have used a heterodyne-type interferometer with a 70-GHz IMPATT oscillator and a 150-MHz oscillator for frequency modulation. The new interferometer consists of a 17.5-GHz phase locked dielectric resonator oscillator and a 37.5-MHz quartz oscillator, as well as frequency multipliers. The main motivation for the new interferometer using frequency multipliers is to achieve a stable and cost effective interferometer. Direct anchor heating experiments with new anchor ICRF antennas in both the west and the east anchor cells have been carried out and density increases in both anchor cells are clearly observed using the new interferometer.

1. Introduction

GAMMA 10 is an effectively axi-symmetrized tandem mirror device which mainly consists of central cell, and two sets of anchor cell, plug/barrier-cell, and end-cell. Since these cells have different roles for plasma production and confinement, magnetic field configurations and production/heating conditions are different in each cell. In GAMMA 10 there are six single-channel interferometers, a multichannel interferometer [1], as well as a 2D interferometer using phase imaging method [2] for electron line density and/or electron density profile measurements in each cell. Most of these conventional interferometers have operated as a heterodyne system with an upconverter using a 70-GHz IMPATT oscillator (microwave source) and a 150-MHz oscillator (IF source) to measure GAMMA 10 plasma densities on the order of 10^{11} - 10^{12} cm^{-3}. However, a high power 70-GHz IMPATT oscillator and other E-band components of an interferometer system are rather expensive and not desirable when many systems operating need to be replaced. Moreover, a 70-GHz IMPATT oscillator has less frequency accuracy and stability than those of lower frequency oscillators.

The major motivation for a new interferometer using frequency multipliers is to achieve a stable and cost effective system.

2. New Interferometer

Figure 1 shows the schematic of the new interferometer using heterodyne system. The microwave source is an internal phase locked dielectric resonator oscillator (PLDRO) having frequency of 17.5 GHz (Microwave Dynamics). 17.5-GHz PLDRO provides high frequency accuracy and stability with low cost and such a frequency band is easy to handle.

The microwave signal is split into the probing beam and the reference beam. The probing beam is frequency modulated in a mixer (Marki) with 37.5 MHz signal from a quartz oscillator system. The quartz oscillator system also provides a signal having frequency of 150 MHz (*i.e.,* the quadrupled frequency of 37.5 MHz) which is utilized for a LO input of a phase detection system. Here we choose the frequency of 37.5 MHz so that we can use the existing phase detection system (150 MHz) utilized in conventional interferometers.

The mixer generates output signal of principally two frequencies 17.5375 GHz and 17.4625 GHz. Here, the LO to RF isolation of the mixer is typically 40 dB. In order to use only 17.5375 GHz, we utilize a band pass filter (K&L Microwave) having center frequency at 17.5375 GHz and stopband attenuation 52 dBc at 17.475 and 17.600 GHz.

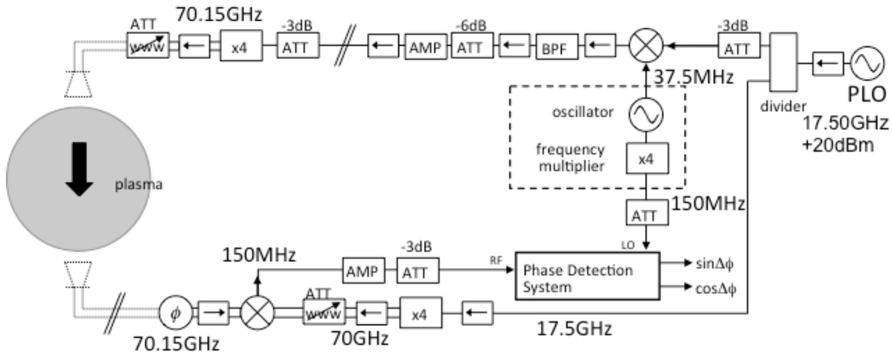

Fig.1. Schematic of the interferometer.

After amplification, the probing signal frequency is upconverted by an active quadrupler (HXI) providing frequency of 70.15 GHz (15 dBm).

The frequency of the reference signal is quadrupled (70 GHz) and then mixed with the signal from plasma by another mixer providing IF output signal (150 MHz). The quartz oscillator system provides the high stability of the IF signal.

3. Experimental Results

The new interferometer is installed on the west anchor cell of GAMMA 10. In GAMMA 10, direct anchor heating experiments with new anchor ICRF antennas in both the west and the east anchor cells have been tested. Figure 2 shows the temporal evolutions of (a) diamagnetism in the central cell and the electron line densities of (b) the central cell, (c) the west anchor cell and (d) the east anchor cell, respectively, in the cases without any anchor heating (the thin lines), with the west anchor heating (85 kW) (the thick lines) and with the east anchor heating (80 kW) (the gray lines). Both the east and the west anchor heatings are applied at t=150 to 190 ms. The line density of the west anchor cell with the east anchor heating is not available at this time due to data acquisition error.

In case without anchor heating, the plasma production and heating conditions are considered to be similar in the west and the east anchor cells, and the line density of the west anchor cell obtained by the new interferometer shows similar behavior as that of the east anchor cell obtained by a conventional interferometer.

Although direct heating effects are clearly shown in both the west and the east anchor cells as density increase of each cell, the effects of the west heating on the line density in the cell where the heating is applied is small comparing to those of the east anchor heating.

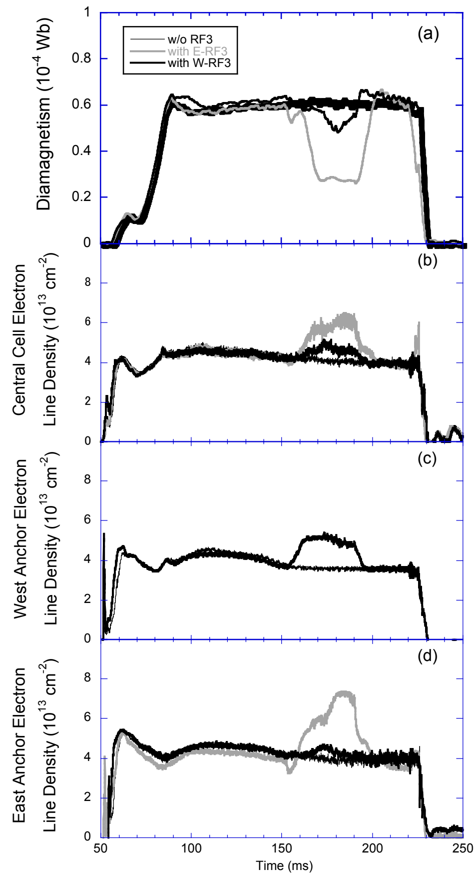

Fig.2. (a) Diamagnetism and electron line density in (b) the central cell, (c) the west anchor cell, and (d) east anchor cell.

References

[1] M. Yoshikawa et al.: Rev. Sci. Instrum. **79** (2008) 10E706.

[2] M. Yoshikawa et al.: Rev. Sci. Instrum. **81** (2010) 10D514.