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Development of a Tangential Sight Line Microwave Polarimeter on TST-2

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In the TST-2 spherical tokamak device, non-inductive start-up of plasma by Lower-Hybrid (LH) waves has been studied. It is considered that a small number of fast electrons driven by the LH waves are responsible for most of the plasma current[1]. LH current drive simulation has been performed to estimate the fast electron distribution function[2]. To validate the calculation, the magnetic field profile inside the plasma needs to be measured. The 27 GHz microwave polarimeter can measure the Faraday rotation angle of the probe light in the plasma to obtain the internal magnetic field information. By superimposing left and right-hand circularly polarized microwaves at different frequencies, linearly polarized light with rotational modulation was generated as the probe light (Fig. 1). Heterodyne measurement is performed by measuring the linearly polarized wave power. For poloidal sight lines, the Cotton-Mouton effect can be eliminated by orienting the antenna to measure either the radial or toroidal component. Previously, we have installed a 4-channel microwave polarimeter with frequencies around 27 GHz on TST-2[3]. However, the measured phase changed by about 10 degrees during the discharge inconsistently from what was expected from the time evolution of the total plasma current.

To investigate the cause of the noise, a bench test simulating the inside of a vessel was created. As a result, it was found that the phase change due to the effect of the wall was less than 1 degree, and we determined that this was not the cause of the 10-degree phase change described above. In addition, the Gunn oscillator's frequency stability was found to introduce phase error up to 1 degree. A bench test of the polarization state of the probe light showed that the polarization was elliptical at the end of the run where it was expected to be circular which have been responsible for the phase error.

In order to validate the measurement principle and identify the cause of phase variation, we decided to test the system with a tangential line-of-sight (Fig. 2). The chord passes through the plasma geometric center $R_0 = 360$ [mm] on the midplane. The expected phase signal is about 40 degrees since the tangential chord measures the toroidal magnetic field. The polarization angle can be predicted accurately for tangential sight lines since it only depends on the toroidal field and the density profiles which are both well measured. The bench test showed that phase noise due to wall reflection for the tangential sight line should be less than 1 degree. By comparing the measured signal with the prediction, we hope to identify the source of the phase error.

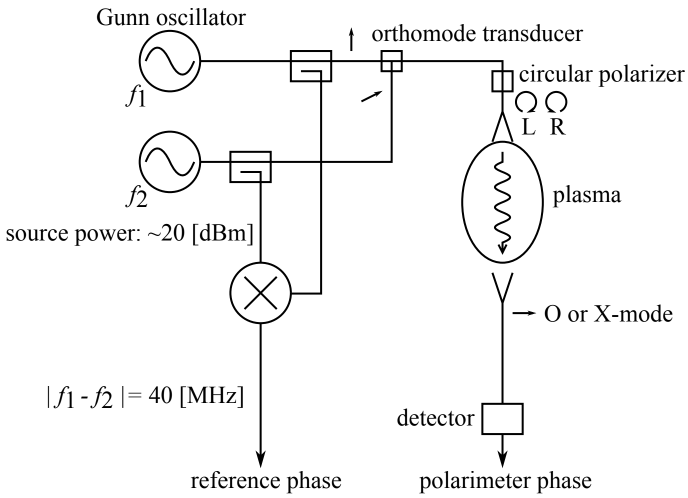

Figure 1: Schematic diagram of microwave circuit.

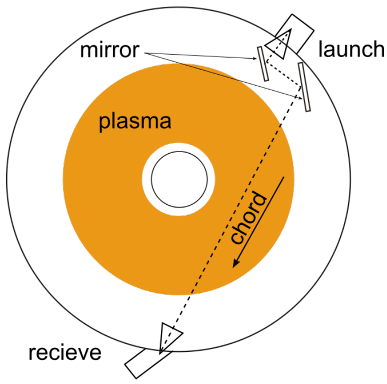

Figure 2: Conceptual drawing of the tangential sight line polarimeter under design.

References

[1] N. Tsujii, et al. Nuclear Fusion 57, 126032 (2017).

[2] N. Tsujii, et al. Nuclear Fusion 61, 116047 (2021).

[3] N. Tsujii, The 38th Annual Meeting of the Japan Society of Plasma Science and Nuclear Fusion Research (2020).