§6. Development of Information Processing System for Microwave Imaging for Plasma and Dielectric Object Observations

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The microwave imaging reflectometer (MIR) measurement system[1] is acquiring valuable data on LHD plasma with well-designed systems of high spatial-temporal resolution antenna array. Meanwhile, on the basis of experiences that we got through construction of these systems, we built a new diffraction microwave imaging system [2, 3] for the purpose of breast cancer diagnostics. The joint research aims to apply new imaging method based on information science approach to the microwave imaging devices that we have already developed. The research also aims to develop practical data processing software for three kind of microwave imaging problem: 1. diffraction tomography (CT), 2. microwave imaging reflectometer (MIR), and 3.synthetic aperture imaging.

1. For the diffraction tomography system, some prototype software components are developed for the rotational scan type CT device. Two types of iterative reconstruction algorithms (Born approximation, extended Born approximation) are implemented by using MQLA(Modified Quasi Linear Approximation). A quick visualization tool of reconstructed results were also developed and tested. The software have been tested with experimental measured data of some kinds of phantoms which has different dielectric constants, and accuracy of resulted images were evaluated (Fig. 1). From the experimental reconstructed result, further three major tasks that should be solved to improve reconstruction performance were found: (1) imaging accuracy can be improved by receiving waves by avoiding reflection waves from object surface (Fig.1). (2) Revision of transfer function that considers wave shortening effect inside the object is required to reduce artifacts which occurred independent of dielectric constants of the object, and occurred when the area of reconstruction is increased. (3)To improve imaging accuracy in the viewpoint of microwave propagation, we should compute time evolution of the entire electro-magnetic field more accurately by embedding FDTD calculation partially in the reconstruction algorithm. We have started to development of the basic part of the software to implement above three solutions.

2. For the LHD plasma refrectometer imaging, the O-mode MIR measurement has started for the purpose to measure density diffraction on isopycnic surface of plasma which could not be measured by the conventional X-mode MIR. Thanks to the revise and improvement of the O-mode devices, the S/N ratio of measured signal has been significantly improved. On the 2-D wavenumber spectral analysis of plasma density fluctuation, we have computed cross spectra of received signal taken from some receiver pairs which are located different spatial measuring position. In the viewpoint of the spectral analysis, if two different receiver pairs have same relative spatial relation, then they have same cross spectra. Therefore, we could check the spectral analysis performance of the O-mode MIR by comparing such two receiver pairs' cross spectra. We have compared some pairs of cross spectra and reviewed problems on current O-mode MIR setup (Fig. 2).

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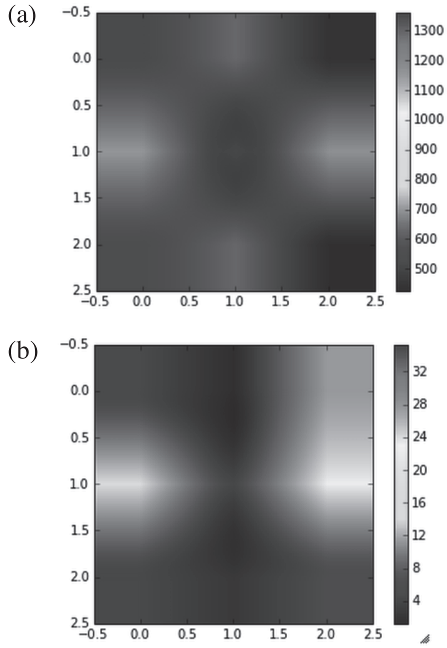

Fig. 1. Experimental reconstructed images of an acryl pillar phantom by rotational CT device: (a) include surface reflection wave, (b) exclude surface reflection wave.

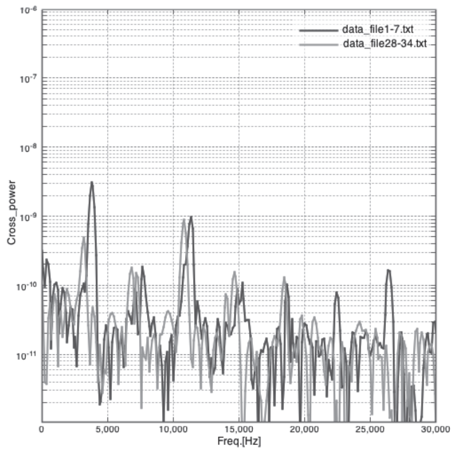

Fig. 2. Cross spectra of plasma experiment measurement of two receiver pairs along toroidal direction of O-mode MIR.

1) Nagayama, Y. et al.: Rev. Sci. Instr., 83, p.10E305-1-10E305-6 (2012).
2) Yamaguchi, S. et al.: Ann. Rep. NIFS 2014, p.189, 445 .
3) Teranishi, M. et al.: Ann. Rep. NIFS 2014, p.466.