A Microwave Interferometer and Polarimeter for the HIT-SI device

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Abstract

Polarimetry has been proposed as a means of non-perturbatively detecting density profiles. This paper studies the use of refractive index detection for one-dimensional interferometers. The existing 140 GHz FTT interferometer [1] capable of high density measurements but has an unreliable wavelength dispersion. In this paper, we propose a super-heterodyne interferometer based on an operating range of 140 GHz to 1 GHz. The system is designed to be sensitive enough to provide angular measurements that can be used to extract density profiles from the interferometer. The design and modeling of the interferometer is presented for various potential architectures.

Physics

The phase principle allows the deviation from the density dependence of the index of refraction in plasma. If magnetic fields are negligible, the density dependence can be calculated in the form:

\[ \phi = \left( \frac{d\phi}{dn} \right) \Delta n \]

The physical principle allows for a polarimeter to be placed in a plasma chamber and measure the density dependence of the index of refraction. The phase change between the traversing signal and the reference signal is then proportional to the density of the plasma.

Electromagnetic waves can be decomposed into LHCP and RHCP waves, depending on the index of refraction, and its disparate values for plasma.

The physical principle utilized by interferometry is the density dependence of the index of refraction in plasma. If the magnetic field is negligible, the density dependence can be calculated in the form:

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Determining the density profile requires the measurement of the phase change with the combinations below.

\[ \gamma = \frac{\phi}{\Delta n} \]

This aids in precise measurement of the density profile as compared to directly monitoring the mixer outputs, as the quadrature using the identity:

\[ \cos(a) \cos(b) = \frac{1}{2} [\cos(a+b) + \cos(a-b)] \]

with the traversing signal, producing a signal of the form

\[ V_{\text{quadrature}} = V_{\text{in}} \cos(\phi) \]

split and part sent through a 90° mixer.

The design and modeling of the interferometer is presented for various potential architectures.

Interferometer & Polarimeter Schematic

![Interferometer & Polarimeter Schematic](Image)

- **Source**: The source emits electromagnetic waves that interact with the plasma.
- **Mirror**: The mirror reflects the waves back to the instrument, allowing for interference measurements.
- **Detector**: The detector measures the phase change induced by the plasma.
- **Polarimeter**: The polarimeter measures the polarization state of the waves, which is related to the plasma density.
- **Mixer**: The mixer combines the reference and traversing signals to produce a quadrature signal.

Expected Interferometry Results

The first stage of development of the microwave diagnostic in the interferometer. Figure shows the interferometer and polarimeter schematic. The interferometer is placed near the plasma to measure the density and magnetic field. The polarimeter is placed near the plasma to measure the polarization state. The interferometer and polarimeter are used in combination to measure the density and magnetic field. The polarimeter data from this instrument could be used to provide a two parameter fit to the lambda profile.

The graph at right shows a linear profile (a=-.45, b=0) and a non-linear profile (a=.75, b=1). The linear profile is the reference profile, and the non-linear profile is the test profile. The interferometer and polarimeter data from the test profile are used to provide a two parameter fit to the lambda profile. The interferometer and polarimeter data from the reference profile are used to provide a two parameter fit to the lambda profile. The interferometer and polarimeter data from the two profiles are used to provide a two parameter fit to the lambda profile.

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Summary

The design of a 2mm microwave interferometer and polarimeter is underway. Measurement of plasma current profile appears feasible. The design and modeling of the interferometer is presented for various potential architectures.