MODULATED SUBMILLIMETER LASER INTERFEROMETER
SYSTEM FOR PLASMA DENSITY MEASUREMENTS

by
Stephen Mitchell Wolfe

Submitted to the Department of Physics on April, 1977 in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

ABSTRACT

A high resolution submillimeter interferometer system for measurement of plasma densities in the $10^{14}$ cm$^{-3} \leq n_e \leq 2 \times 10^{15}$ cm$^{-3}$ range has been developed for use in high density tokamaks. Phase modulation at 1 MHz is accomplished by difference frequency mixing of two cavity tuned laser oscillators. The optically pumped methyl alcohol lasers, which operate on the 118.8 µm line, feature a novel output coupling design, the capacitive grid coupler, that permits good mode quality and low beam divergence. The beat signals are detected in Ge:Ga photoconductor detectors, and a direct measurement of the phase shift is obtained from the lag between probe and reference signals. A continuous measurement of the evolution of the density in time is obtained with frequency response up to 200 kHz.

The system has been used to measure plasma density on the Alcator device. For this device a phase shift of $2\pi$ (one fringe) is equivalent to a line averaged density of $1 \times 10^{14}$ cm$^{-3}$. As many as six fringes have been observed, corresponding to an average density of $6 \times 10^{14}$ cm$^{-3}$ and central density of $10^{15}$ cm$^{-3}$. 
The predominant noise in the system is due to vibrations of the mechanical support structure of the interferometer induced by stray fields from the Oh transformer. At worst these correspond to errors of 0.1 fringe or $1 \times 10^{13}$ cm$^{-3}$. The observed signal to noise is typically better than 20:1 even on shots with density of only $1 \times 10^{14}$ cm$^{-3}$. 