I  INTRODUCTION

Because of the difficulty of understanding particle and energy confinement in experimental devices aimed at the goal of producing magnetic fusion energy, new diagnostics to understand these processes are constantly being sought. Of particular interest are diagnostics to measure the local spatial value (as opposed to chord integrated) of fluctuating quantities in present experiments, and diagnostics to measure the local value of any of the important plasma parameters in a true fusion reactor environment (i.e., in a high radiation environment). As discussed below, we (my graduate students and myself) have shown that crossed-sightline ECE (electron-cyclotron-emission) can be used for both local measurement of fluctuating quantities (electron temperature and density), and also for inferring the local value of the absolute magnetic field in present experiments, or in a reactor environment. The absolute magnetic field measurement is a direct measure of the local plasma pressure ($\beta$) in currentless devices, and in combination with temperature and pressure measurements is a measurement of the plasma current density in devices with significant plasma current. The work on fluctuations (electron density and temperature) is being pursued (continued) under...
a separate contract in collaboration with Auburn University, Oak Ridge National Laboratory, and the University of Texas. The work on absolute measurement of magnetic fields is unfunded at this writing, but follow-on work will be proposed this fall in collaboration with InterScience, Inc., and/or the C.I.T. project or Alcator-C-Mod projects. Our calculations show that absolute measurements of magnetic field can be made to the order of 0.1%, even in a reactor environment, and that a scanning ECE system could be used to measure the beta profile or current profile in a reactor, as appropriate. The electron temperature fluctuation measurements have a similar resolution, and can also show the phase between density and temperature fluctuations, an extremely important quantity for understanding transport caused by these fluctuations.

II REPORT

The results of our studies on measurement of absolute magnetic field, measurement of beta and/or poloidal magnetic fields, and measurement of parallel magnetic field fluctuations have been published in the Review of Scientific Instruments, volume 61, issue No. 2 (February), of 1990. The article by G.R. Hanson (a Georgia Tech graduate student partially supported under this contract) and C.E. Thomas is attached to this report as enclosure (1). The article discusses our research in considerable detail, but can be summarized rather briefly. It is demonstrated that absolute measurements of magnetic field and of parallel magnetic field fluctuations by using crossed-sightline ECE correlation can be made with an accuracy of 0.1%, with a spatial resolution the order of 1 cm or better and with a time resolution of the order of 100 microseconds on both the TEXT and CIT devices (similar resolution could be expected for the Doublet Big-D device at General Atomics, and for TFTR). It is further demonstrated that beta could be measured on a currentless device with the same accuracy (this follows immediately), and that the current profile could be measured with an accuracy of better than 90% over the outer 80% of the plasma radius (i.e., from r/a=0.2 to r/a=1.0). The diagnostic is predicted to be extremely useful for absolute magnetic field profile measurements in burning devices or reactors, because the only components near the reactor are metallic mirrors and/or waveguides, which are extremely resistant to radiation
damage. The diagnostic also has the advantage of being a passive device, no beams, lasers or physical penetration of the plasma are required.

The use of the ECE diagnostic to measure electron temperature and density fluctuations has been presented as a paper at the Conference on High Temperature Plasma Diagnostics at Cape Cod in May, 1990. The paper prepared for this meeting presents the research to date on this subject in great detail, and is attached as enclosure (2). The basic results of this study are that electron temperature fluctuations of 0.1% can be resolved with a spatial resolution of the order of 1 cm. The frequency resolution of the diagnostic is of the order of 1 kHz or better from 10 kHz to 500 kHz, but the plasma must be steady-state (the fluctuation amplitude must be approximately constant) for 10 milliseconds in order to achieve this resolution. Diagnostics to implement this concept are presently being built for both ATF and TEXT (under a separate contract in collaboration with Auburn, ORNL, and Texas). The resolution discussed above is more than an order of magnitude better than any previous measurement of temperature fluctuations in a high temperature plasma. Simultaneous measurement of the relative phase and amplitude of density fluctuation will be attempted in a later phase after the temperature fluctuation measurements are successful.

III SUMMARY

In summary, we believe that DOE has gotten excellent value for its investment under this contract, with the promise of outstanding new diagnostics for both present day fusion experiments, and for fusion reactors.

DISCLAIMER

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