PROGRESS REPORT

MEASUREMENT OF IMPURITY ION DENSITIES AND ENERGIES IN THE DIVERTOR AND EDGE REGIONS OF ALCATOR C-MOD TOKAMAK

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Introduction

Magnetic divertors play an important role in controlled fusion research involving tokamaks. We will investigate impurity production and transport in the divertor and edge regions of the Alcator C-Mod tokamak through spectroscopic techniques. We will perform high resolution time-resolved measurements of impurity line widths and shifts in the UV-visible spectral region in order to obtain ion temperatures and ion flow velocities. Our emphasis is on low ionization states found near the divertor plates which are more indicative of the physical processes related to impurity generation and particle and energy transport in this region.

Objectives

There were three primary objectives of the initial phase of this investigation. First, we planned to test an existing University of Maryland 0.75-meter spectrometer and prepare it for installation on Alcator C-Mod. This would provide a modest resolution instrument for initial survey spectra. Second, we planned to install this instrument on Alcator C-Mod as soon as it became operational. This would allow us the opportunity to integrate into the Alcator C-Mod data acquisition system and determine the light intensity level. Third, we would specify and order a high resolution 2.0 meter spectrometer and two-dimensional charge coupled device (CCD) array detector based on the experience gained from the initial measurements.

Results

Instrumentation

We have tested a 0.75-meter Czerny-Turner spectrometer with a 1200 g/mm grating. Attached to this spectrometer is a Princeton Applied Research intensified linear diode array which can be scanned every 30 msec. From our experience with this system, we know that a $0.8 \text{ \AA}$ instrumental width and a $0.2 \text{ \AA}$ wavelength accuracy can be obtained. This instrument will view the interior of Alcator C-Mod through K-port using a quartz optical system. We plan to transport the spectrometer to MIT as soon as Alcator C-Mod becomes operational. Until that time we will continue efforts to integrate the control of the linear diode array into Alcator C-Mod's data acquisition system.

We have obtained a 35-meter quartz fiber optic bundle from Jim Terry at MIT and have tested the transmission of the fiber at various wavelengths. The fiber is to be used to couple the spectrometer to the telescope that will be used to view the divertor region. The results of the transmission test indicate that the signal will be reduced by a factor of 10 to 100 by the cable, depending on the wavelength of the light (see below for a solution to this problem).

To improve our spectral resolution we are purchasing a 2.0-meter spectrometer which will have a larger dispersion than the present instrument. By choosing a grating blazed for long wavelength and viewing higher orders in the spectrum, we expect to

achieve an instrumental width of $0.1 \text{ \AA}$ and a wavelength resolution of better than $0.05 \text{ \AA}$. Coupled to this spectrometer will be a 2-D CCD array detector which will offer better signal to noise response than our present detector and allow for multiple simultaneous spectra. We have requested supplementary funding for the 2-D detector and expect to order it soon after September 1, 1992.

Data Acquisition

The PAR linear diode array is controlled by a Macintosh computer with software that was developed at the University of Maryland. The software has been modified for the mode of operation desired at MIT and extended memory has been installed to allow for recording 100 spectra per shot. Initial measurements will be recorded on the Macintosh and transferred to the Alcator C-Mod database.

A trip was made to MIT in early May and we were briefed on the Alcator C-Mod data acquisition system. Because of the large amount of data to be transferred, it was recommended by MIT that a high speed connection (GPIB) should be made between the diode array and the Macintosh computer and a direct high speed link (Ethernet) be made between the Macintosh computer and the Alcator C-Mod database. These connections have been purchased and are being integrated into the software used to control the diode array. During the MIT visit it was also decided that the spectrometer should be located in the cell with Alcator C-Mod rather than located remotely. This allows for less attenuation of the NUV signals, however it restricts

access to the instrument between shots. Because of the limited access, wavelength and slit width controls must be operated remotely. This will require stepper motors, controller cards, and a communications link to the Macintosh computer as well as software to determine a wavelength calibration from the stepper motor location. This hardware is presently being investigated.

Analysis

Spectra from the first few ionization stages of Molybdenum have been recorded from a sliding spark source at the University of Maryland. Approximately 700 lines have been observed from 2000 to 6000 Å. Efforts are underway to identify the stronger of these lines and determine the ionization stages present. This information will aid in the interpretation of spectra obtained from Alcator C-Mod.

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