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1992 ANNUAL REPORT

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EDGE DENSITY FLUCTUATION DIAGNOSTIC
FOR DIII-D USING LITHIUM BEAMS

GENERAL ATOMICS PROJECT 3879

BY DR. DAN M. THOMAS

1. Overview. The goal of this diagnostic is to provide detailed information about the behavior of the electron density in the edge region of DIII-D, and in particular to examine the local character of the associated fluctuations in this region. These fluctuations are believed to play a key role in the transport of energy and particles out of tokamaks and the associated degradation in confinement properties. Measurements should provide important data for testing theories of the L-H transition in tokamaks and should help in assessing the role of various instabilities in anomalous transport.

To provide this information we are developing and implementing a diagnostic system based on injecting an intense low energy neutral lithium beam into the plasma periphery¹. The beam undergoes exciting and ionizing collisions with plasma particles as it transits the region near the separatrix. The resulting fluorescence from the excited 2P state is collected and measured as a function of position in the plasma using either one- or two-dimensional optical detector arrays. This localized determination of the fluorescence intensity may be related to the localized values of plasma parameters, in particular the plasma density behavior, via a set of coupled rate equations incorporating the appropriate atomic cross-sections. Because of the favorable atomic properties of lithium (high excitation rate, low beam temperature, resonance wavelength well separated from H _{α} background light), we believe that the beam, although attenuated, should still provide information about the density behavior up to several centimeters inside the separatrix with good spatial (<1 cm) and temporal (<10ms) resolution. This is precisely the region believed to be responsible for the creation, under the proper conditions, of an edge transport barrier; i.e., the H-mode.

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2. Results during 1992.

During the past several months the Lithium beam diagnostic was commissioned on DIII-D and began yielding useful information. We developed the remote control and monitoring of the ion source operation and beam formation and focussing, and integrated the control system and data acquisition into the DIII-D operating system. We fabricated several detector types and collected fluorescence data using several differing detector arrangements. Beam-gas measurements were conducted to analyze the intrinsic beam fluctuations and stability. Fluorescence data was then obtained on a number of Tokamak discharges under varying discharge conditions.

Analysis of this initial data is proceeding but has already yielded some interesting features. These include changes in the edge plasma density behavior during the l-to h-transition, disruptions, and edge localized modes (ELMs). Based on the quality of data obtained we proceeded with the design and construction of the full 16-channel detection system which will be completed and tested shortly.

Our plans for the future include pursuing the edge density measurements, attempting to extend the technique to allow localized impurity measurements for Charge Exchange Recombination (CER) purposes, and extending the two-dimensional capability by imaging the beam with a gated, intensified CCD camera. Most of these will be attempted during the next run period scheduled to begin in February.

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DIII-D Lithium Beam Diagnostic

5-30 keV, 5-10 mA equivalent, injected near radially.
Beam viewed tangentially through nearby window.

Collisionally-induced fluorescence from beam collected and imaged
onto fiber optic array, transmitted to discrete filter/detector assemblies.
(16-channel upgrade underway)

System provides information about edge density behavior with
excellent spatial (6 mm) and temporal ($1\ \mu\text{s}$) resolution.
Both radial and poloidal data may be acquired simultaneously.

Direct, continuous information obtainable on:
correlation lengths (radial and/or poloidal)
L-H transition effects
ELMs

Flow Visualization of Plasma Turbulence

- measurements of local fluctuations and correlation lengths are important, but not the whole story.
- ability to visualize or image turbulence a valuable additional tool.
- evidence of coherent structures in edge of some machines from probe experiments (CCT, TEXT, Caltech,...).
- further investigations need:
 - measurements deeper into plasma edge
 - nonperturbative techniques
 - good spatial and temporal resolution
- Edge BES using Lithium Beam an excellent candidate.

Correlation Measurements

The cross-correlation between two detector channels spaced 2.3 cm apart in the edge of a DIII-D discharge (approximate locations are $r = 229.3$ cm and $r = 227.0$ cm). Time proceeds down the page on this plot. Shot 76201 had an L-to H- transition at around 3950 ms and the data shows a marked decrease in the cross-correlation around this time. This effect is most notable at low frequencies but extends to quite high frequencies.

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Future Directions

- Continue measurements with the discrete detector system using different viewing arrays to get simultaneous poloidal and radial data. Begin to examine the two-dimensional $S(k, \omega)$.
- Existing beam may be detuned to yield a somewhat broader (i.e. more poloidal) interaction region in the edge, but upgrade of source and neutralizer to provide a strip beam will enhance signal.
- Direct two dimensional imaging of the beam using a gated, intensified CCD camera will yield extremely precise spatial information-- a "snapshot" of coherent structures in the edge of DIII-D

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