Measuring the Plasma Impurities in Alcator C-Mod as a Function of Time

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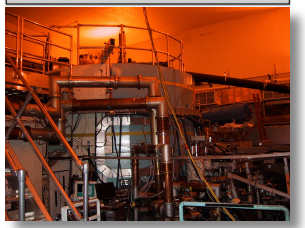
Introduction:

A flat-field grating spectrometer has been installed on the Alcator C-Mod tokamak at Massachusetts Institute of Technology. This spectrometer is being used to track the presence of impurities inside the plasma of the Alcator C-Mod. The ability to know what impurities are in the plasma, the quantity of, and the how they behave is vital for experiments taken with the Alcator C-Mod. With the usage of the flat-field spectrometer the effects of unwanted impurities, caused by sputtering from the Alcator C-Mod's structure, can be analyzed. Other impurities, such as tungsten, that are injected into the plasma by a laser blow-off system, can be analyzed to retrieve information about the rotation and temperature of the plasma.

The Alcator C-Mod

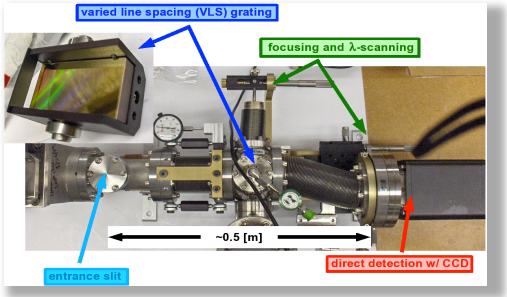


The Alcator C-Mod is a high magnetic field tokamak plasma confinement experiment located at MIT.

Methods:

The flat-field grating spectrometer has a variable space grating of 2400 lines/mm with a range of 10<λ<70 Å in a single setting. The spectral image is focused on a soft x-ray sensitive Princeton Instruments CCD camera with a time resolution of approximately 5 ms. Data collected from the flat-field spectrometer is analyzed to give detailed information of the evolution of impurities as a function of time.

The flat-field grating spectrometer.

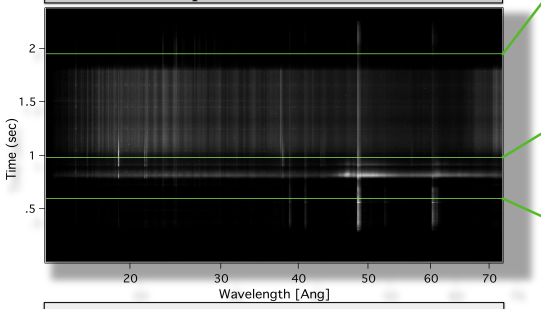


The flat-field grating spectrometer that is in operation at Alcator C-Mod was designed, built, and calibrated at the Fusion and Astrophysics Data and Diagnostic Calibration Facility at Lawrence Livermore National Laboratory.

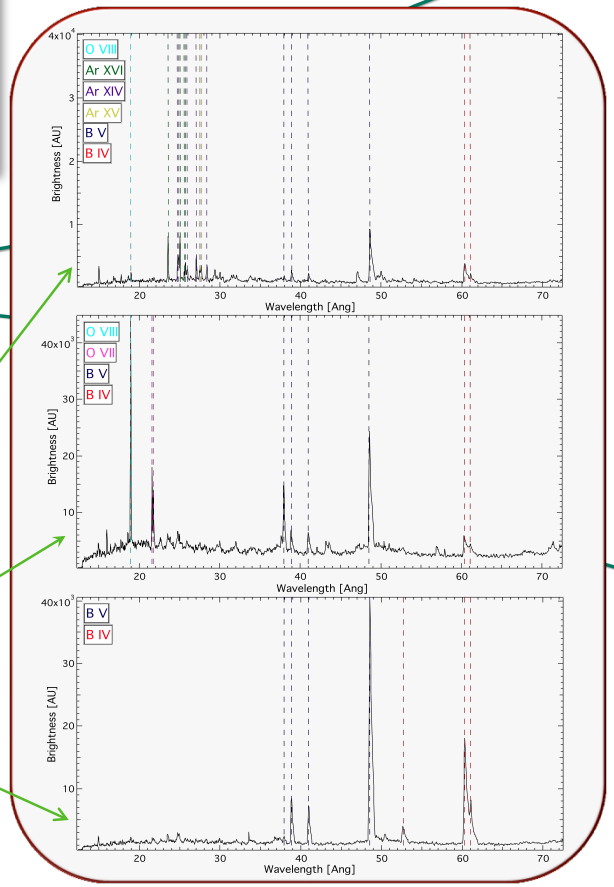
Results:

The flat-field spectrometer gave us clear spectra of the impurities in the plasma. The graph bellow shows the intensity of the atoms in the plasma throughout the time period of one run of the Alcator C-Mod (little over 2 seconds). Each line can then be analyzed to see what impurities were in the plasma during the run and how they evolve during the shot. The graphs to the right show three different lineouts taken from a single run. The notable impurities found in the plasma were boron, oxygen, and argon.

Flat-field spectrum as a function of time.



Time versus wavelength image of the spectrum measured with the flat-filed grating spectrometer at Alcator C-Mod. Each row represents a 5 ms integration. The presence of different ion species as a function of time is easily observed.



Discussion:

The installation of the flat-field grating spectrometer on the Alcator C-Mod gives researchers great support for monitoring impurities in the 10<λ<70 Å wavelength range. As a future high school physics teacher this project on the Alcator C-Mod is a great example of how spectroscopy is being used to advance the frontier of fusion energy. Students will be able to see the significance of spectroscopy and how scientists can use the wavelengths given off by excited atoms in plasma to deduce the important characteristics of plasma such as its make up, temperature, and rotation. Another emphasis for students is the ability to use programs such as Igor Pro to process and analyze raw data taken from experiments.

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