VUV Impurity Spectroscopy on the Alcator C-Mod Tokamak


a) Plasma Science and Fusion Center, MIT, Cambridge, MA
b) Physics Division, Lawrence Livermore National Laboratory, Livermore, CA
c) Space Sciences Laboratory, Berkeley, CA

DIAGNOSTIC OVERVIEW

IMPURITY MONITORING

IMPURITY TRANSPORT

ATOMIC PHYSICS

ASTROPHYSICS

C-Mod’s VUV spectroscopic tools help to validate density-sensitive line ratio modeling relevant to astrophysics.

The boron iso-electronic sequence is being studied1,2 for use as a density diagnostic in high-temperature astrophysical plasmas.

- Population of 2s2p line structure levels in L-shell emission.
- Electron impact excitation out of the 2s2p(2P0,2) and 1S0 states is different for each excited state.

2p-3d line ratio inversion is a strong function of Z, 5x10^26 [cm^-3] for Ar XIV to 4x10^19 [cm^-3] for Fe XXII.

Ar XIV 2p-3d ratio matches and extends previous results:

- Pulled into ohmic plasmas with density ramp.
- 2p-3d line ratio calculated using Sobolev Gaussian fit to fall-off spectra.
- Ratio measured to be 1.85 ± 0.03 over a wide range of plasma density, electron temperature, and electron density.
- Matches previous NSTX results, enabling higher n, and demonstrates asymptotic behavior.

Ar XIV

Fe XXII 2s-2p 3p-4s 4s-4p using Rowland circle spectrometer

The enhancement of the high-n Lyman series is a potential diagnostic for:

- NEUTRAL DENSITY if the B’ profile is known from beam-based C-X.
- B-DENSITY if known from H-x or Ly-β emission
- B-TEMPERATURE/VELOCITY if viewing a localized neutral gas puff.

High quality, resolved thermal c-x cross-sections need to be calculated for more than boron for techniques to be extended to an arbitrary low-Z impurity.

N VII: Lyα > Lyβ

Observed line corresponds to where the n=1 thermal c-x cross-sections peak

With a neutral gas puff, Fe B’(n=7-6) line at 4964 Å is used for Doppler spectroscopy. This is calibrated by Fe XXII with m=2 hydrogen.

The enhancement of the high-n Lyman series is a potential diagnostic for:

- NEUTRAL DENSITY if the B’ profile is known from beam-based C-X.
- B-DENSITY if known from H-x or Ly-β emission
- B-TEMPERATURE/VELOCITY if viewing a localized neutral gas puff.

High quality, resolved thermal c-x cross-sections need to be calculated for more than boron for techniques to be extended to an arbitrary low-Z impurity.

Ar XIV

Fe XXII 2s-2p 3p-4s 4s-4p using Rowland circle spectrometer

The enhancement of the high-n Lyman series is a potential diagnostic for:

- NEUTRAL DENSITY if the B’ profile is known from beam-based C-X.
- B-DENSITY if known from H-x or Ly-β emission
- B-TEMPERATURE/VELOCITY if viewing a localized neutral gas puff.

High quality, resolved thermal c-x cross-sections need to be calculated for more than boron for techniques to be extended to an arbitrary low-Z impurity.

Ar XIV

Fe XXII 2s-2p 3p-4s 4s-4p using Rowland circle spectrometer

The enhancement of the high-n Lyman series is a potential diagnostic for:

- NEUTRAL DENSITY if the B’ profile is known from beam-based C-X.
- B-DENSITY if known from H-x or Ly-β emission
- B-TEMPERATURE/VELOCITY if viewing a localized neutral gas puff.

High quality, resolved thermal c-x cross-sections need to be calculated for more than boron for techniques to be extended to an arbitrary low-Z impurity.

Ar XIV

Fe XXII 2s-2p 3p-4s 4s-4p using Rowland circle spectrometer