Spectroscopic Diagnosis of Plasma in the IEC

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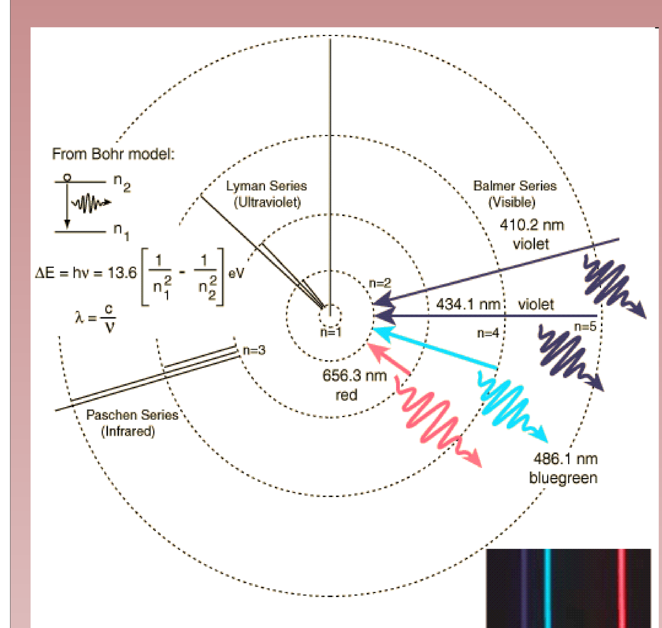
Charge Exchange Emission Spectroscopy

This diagnostic technique noninvasively provides information on

- Atomic and molecular species
- Spatially resolved species energy
- Gas Temperature

Excited species in a plasma emit photons under a variety of processes. In a Hydrogen plasma the charge exchange predominately produces excited neutrals that can be spectroscopically measured.



Charge Exchange reactions dominant in spectroscopic measurement of Hydrogen:

$H^+ + H_2 \rightarrow H^* + H_2^+$

$H_2^+ + H_2 \rightarrow H^* + H + H_2^+$

$H_3^+ + H_2 \rightarrow H^* + H_2 + H_2^+$

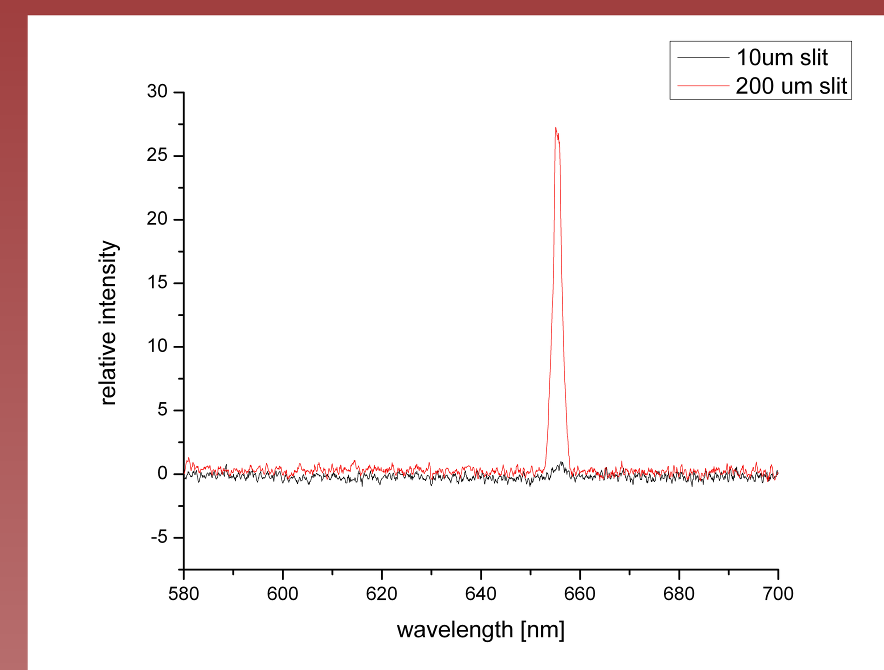
The observed wavelength of the photons emitted by excited atoms is Doppler shifted

$$\Delta\lambda = \frac{v\lambda_o}{c}\cos(\theta)$$

Lighter species will reach a higher velocity than the heavier species, allowing a measurement of relative accelerated molecular population as well as energy distribution information in a variety of IEC conditions.

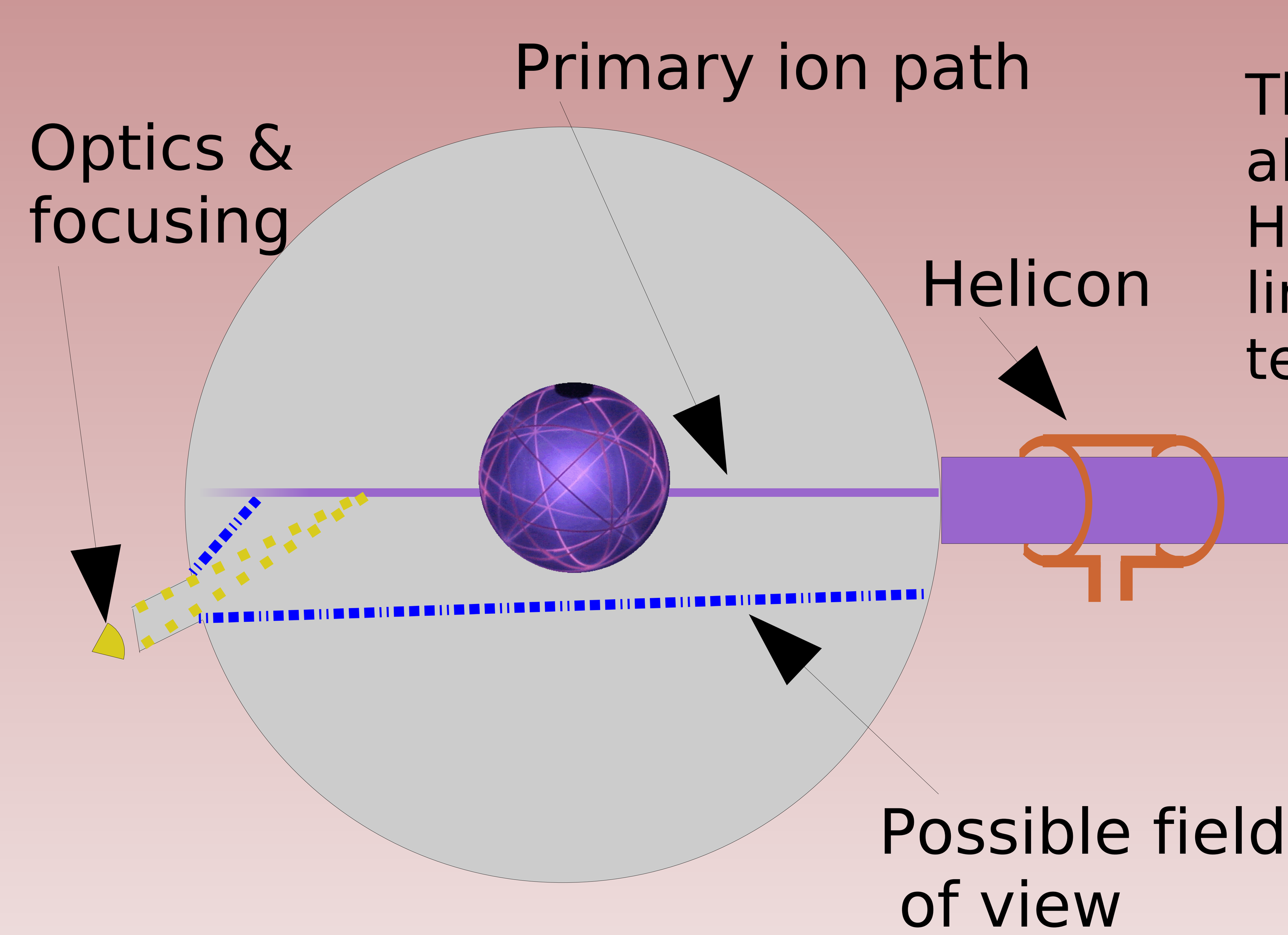
With acknowledgments to the Grainger Foundation

Measuring the IEC



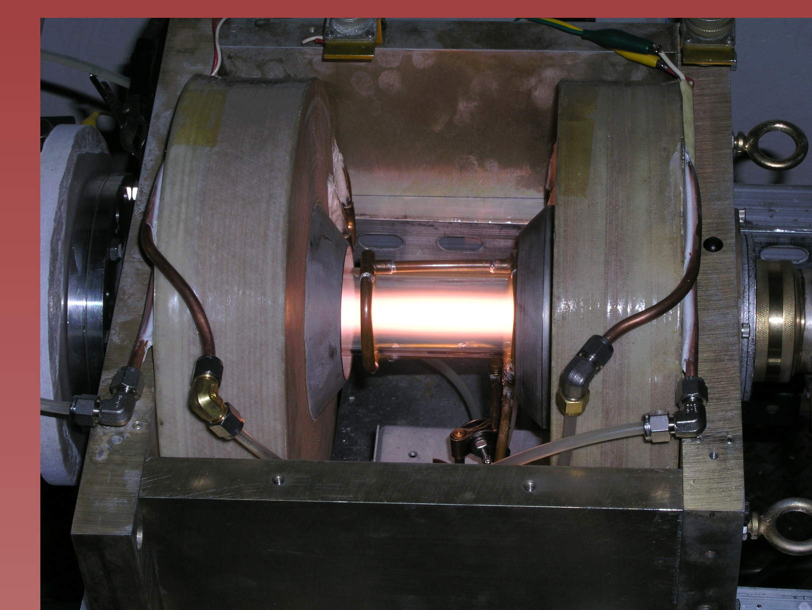
35kV, 30mA, 1.6 Pa (12 mTorr)

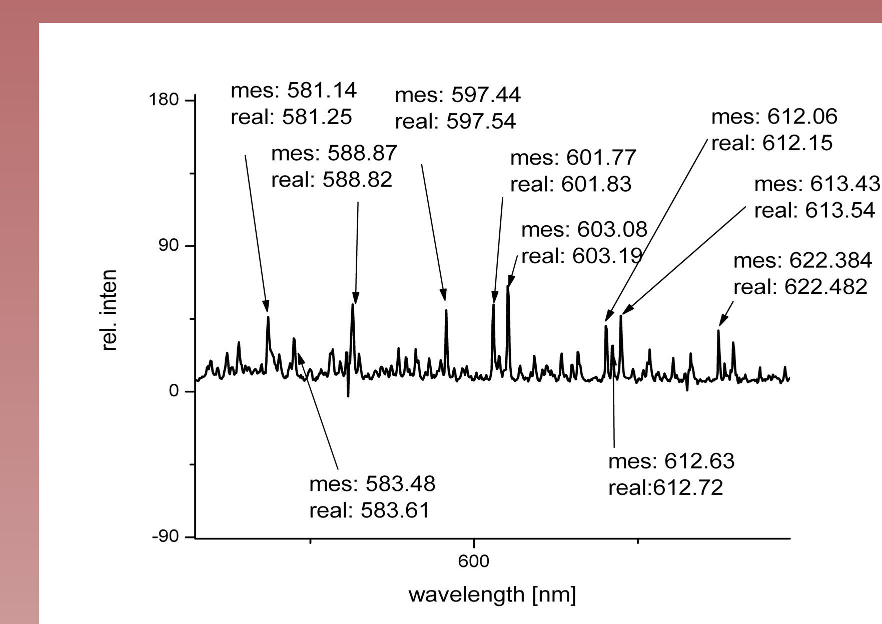
Initial spectroscopic measurements of the IEC have been taken in glow discharge mode. An inherent trade between resolution and signal intensity exists.



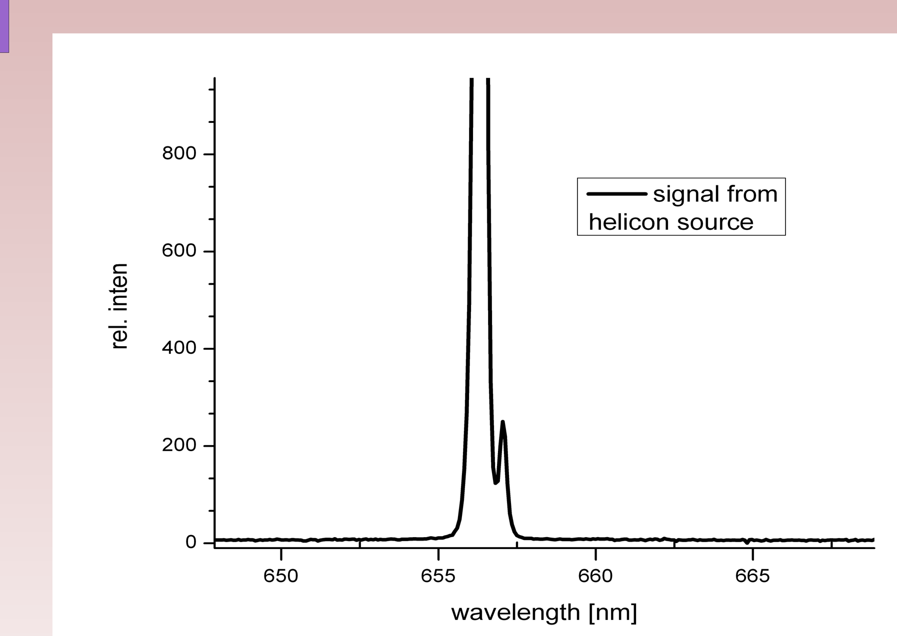
Diagnosis of the IEC will proceed by examining the primary beam path produced when using the helicon source in the IEC. By focusing on points along the beam path a detailed ion energy spectrum can be spatially resolved.

Measuring the Helicon





The intensity of the helicon plasma allows the measurement of molecular Hydrogen lines. Theoretically, these lines can be used to measure gas temperature.



A close-up of the H_α (656.3 nm) line from the helicon shows a persistent Gaussian peak about at 657.0 nm. The source of this signal is not yet identified.

Future Work

This diagnostic will be applied to a variety of plasma species to diagnosis device physics:

- D I – determining molecular distribution of D in the IEC
- He I – yielding He3 behavior in the IEC
- Ar I/II - contrasting ion and neutral behavior in the IEC

This campaign will probe regimes in IEC operation not yet explored spectroscopically.

Conclusions

- Preliminary spectroscopic measurements of the IEC have been taken, with promising results.
- Spectroscopic analysis of a helicon is possible in regimes that physical probes cannot survive.
- The UW spectroscopic diagnosis campaign will expand into operating regimes previously unexplored spectroscopically.