The Effect of Laser Pulse Width on the Behavior of UF_6 Plasma in LISA-UE

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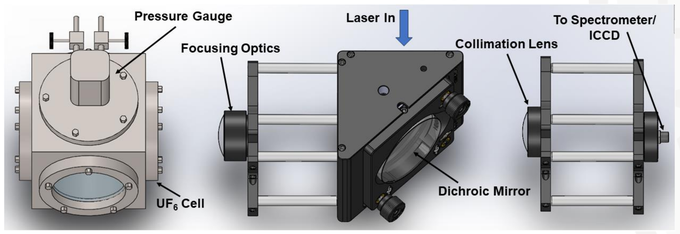
Introduction and Motivation

- IAEA is interested in the development of fieldable instruments to determine the enrichment of gaseous UF_6.
- Laser-Induced Spectrochemical Assay for Uranium Enrichment (LISA-UE) uses laser-induced breakdown spectroscopy and spectral fitting for this purpose.
- We performed a fundamental study of the region around the U I 646.49 nm line and especially the effect of laser pulse width.

Chan et al., *Appl. Spectrosc.*, **77**(8):819-834 (2023).

Technical Approach



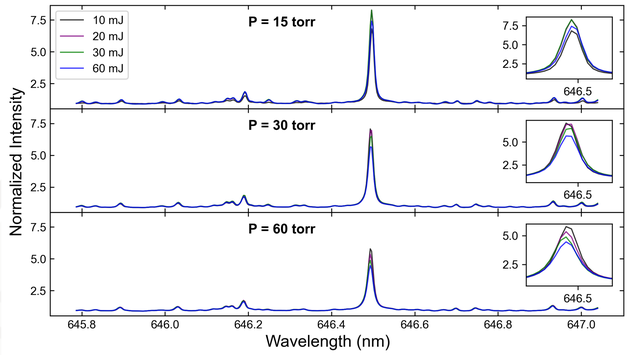
Laser sources compared:

- 4 ns, 1064 nm Nd:YAG
- 40 ns, 1064 nm Nd:YAG
- 100 fs, ~800 nm Ti:sapphire

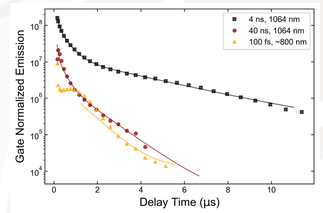
Spectral lines modeled as Lorentzians:

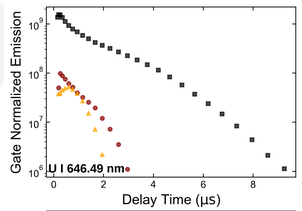
$$I(\lambda) = \frac{H\omega^2}{4[(\lambda-\lambda_0)^2]-\omega^2} + c_0$$

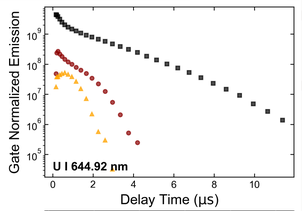
Results



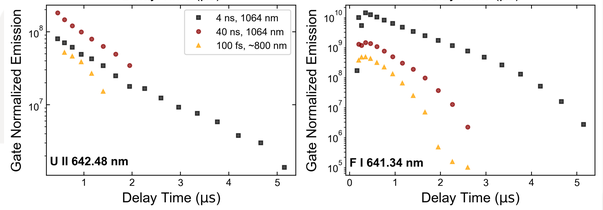
The spectral region around the atomic U I 646.49 nm line is insensitive to laser energy and changes in gas pressure.

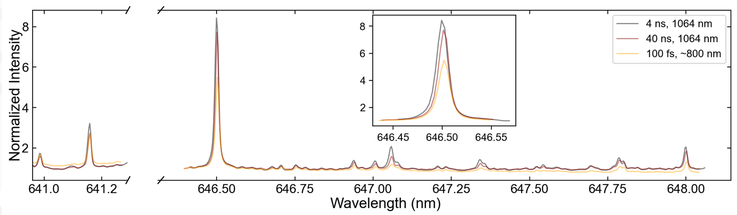


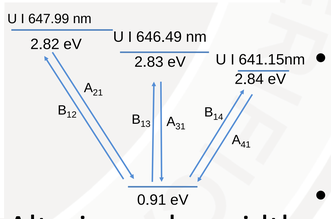




A long-lived continuum relative to spectral feature decay is observed.







Source	646.49/ 647.99 nm	646.49/ 641.15 nm	646.49 S/B
4 ns, 1064 nm	7.20±0.09	3.15±0.02	7.61±0.03
40 ns, 1064 nm	8.00±0.36	3.38±0.07	7.26±0.12
100 fs, ~800 nm	8.86±0.22	2.73±0.06	4.77±0.08
Reference	**13.48±0.20**	**5.14±0.06**	-

Altering pulse width does not significantly change self-absorption. No laser source demonstrates clear measurement advantages.

Impact and Relevance

- Improved understanding of UF_6 plasma behavior enables the optimization of future measurements
- LISA-UE could greatly decrease the time required for enrichment facility inspection
- Improve global capabilities for ^{235}U monitoring
- Work has been performed in collaboration with Lawrence Berkeley National Laboratory

Conclusion and Future Work

- The U I 646.49 nm continues to show promise for enrichment measurements. However, self absorption may limit accuracy.
- Future work will compare measurements performed with excitation sources of varying wavelengths.
- A measurement correction factor and model are under development:

Absorption coefficient:

$$\alpha(\lambda) = \pi r_0 \lambda^2 f_{ij} n_0 P(\lambda)\left(1 - e^{-hc/\lambda kT}\right)$$

Voigt profile line shape:

$$P(\lambda) = \int_{-\infty}^{\infty} G(\lambda) * L(\lambda - \lambda')d\lambda'$$

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