Forensic Signatures from Laser-Induced Resonance Ionization

MTV Kickoff Meeting

(Date of your presentation)

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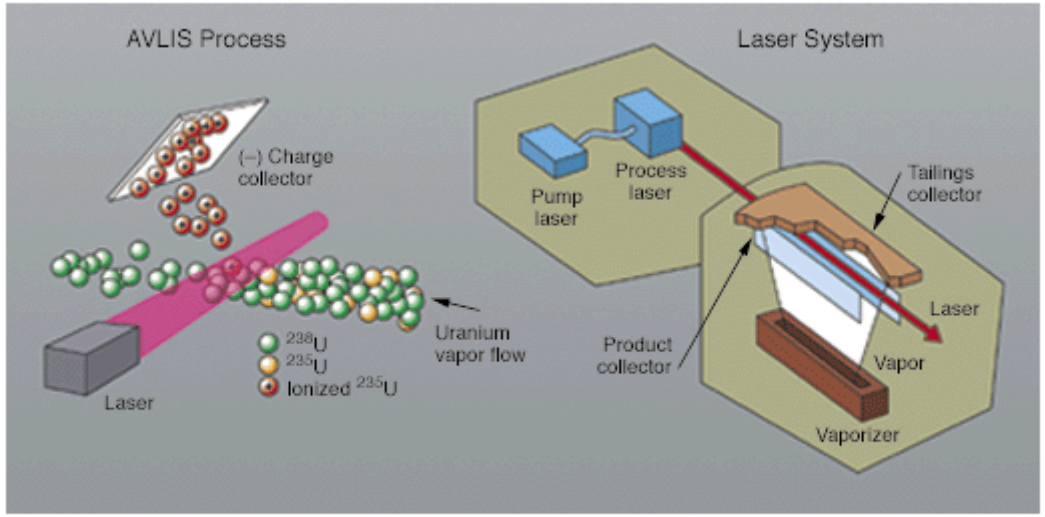
Introduction and Motivation

- Laser induced excitations of may be utilized to isotopically separate uranium.
- Techniques have been developed including:
  - Molecular laser isotope separation (MLIS): an isotopic-selective multi-photon photodissociation process acting on a molecular species (UF_6).
  - Atomic vapor laser isotope separation (AVLIS): an isotopic-selective resonance photoionization process acting on an atomic species (vaporized atomic uranium).
- From a nuclear nonproliferation perspective, resonance excitation methods for isotope enrichment poses a threat for nations or entities to develop clandestine facilities for isotope separation.

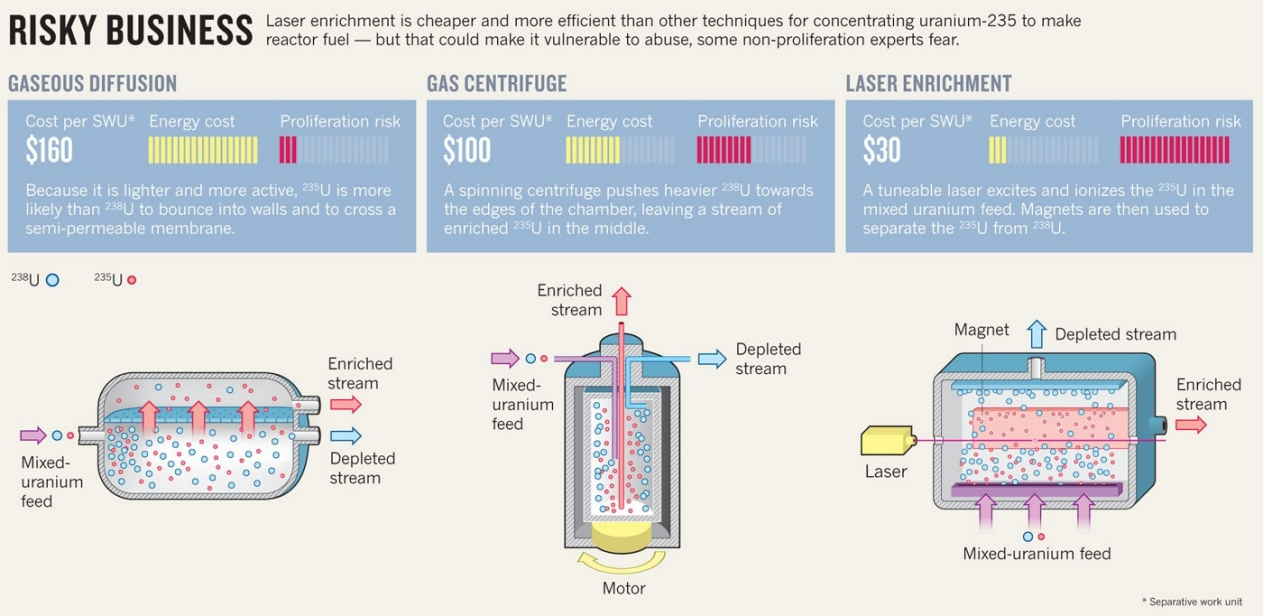


In the laser system used for the LIS uranium enrichment process (right), electrons from the ^{235}U atoms are separated (left), leaving positively charged ^{235}U ions that can be easily collected for use.

https://str.llnl.gov/str/Hargrove.html

Mission Relevance

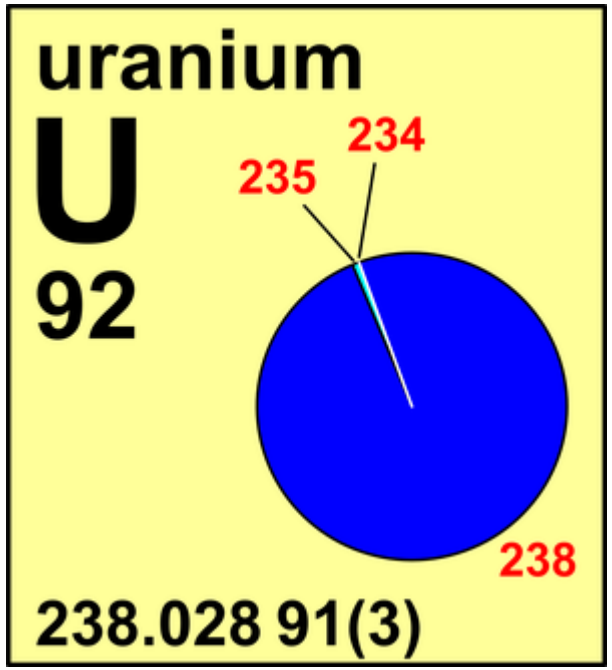
- Uranium enrichment is a key technology of interest for a proliferating nation.
- DOE NNSA's mission to prevent the nuclear weapon proliferation has a clear connection to reduce the pathways to obtain high enriched uranium.
- Laser enrichment evaluations are necessary for a comprehensive non-proliferation strategy.



https://www.nature.com/news/us-grants-licence-for-uranium-laser-enrichment-1.11502

Technical Work Plan

- This work aims to further develop an understanding of chemical and physical processes involved with laser resonance excitation methods.
- Nuclear, chemical, and material morphology signatures will be identified to be utilized as forensic indicators of these isotope separation methods.
- As an example, laser resonance excitation enrichment of ^{235}U leads to a unique isotopic signature of $^{234}U/^{238}U$ that is distinguishable from diffusion or centrifugal enrichment methods.



Isotope	Atomic Weight	Isotopic Abundance
^{234}U	234.040	0.000054
^{235}U	235.043	0.007204
^{238}U	238.050	0.992742

http://ciaaw.org/uranium.htm

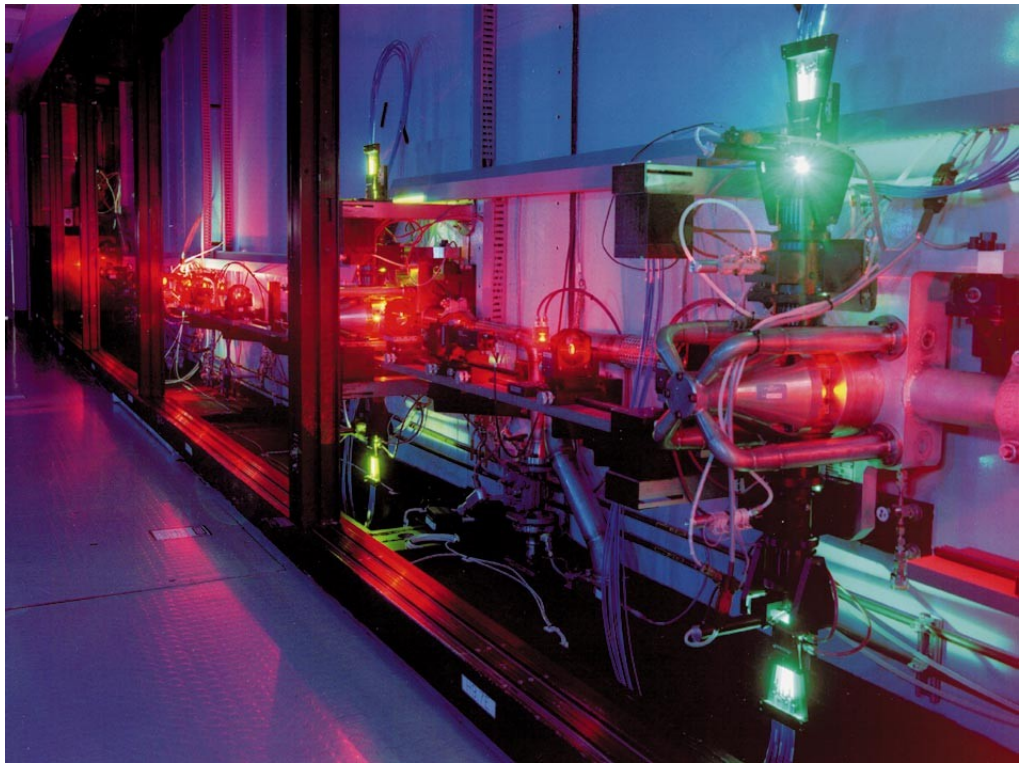
Technical Work Plan (continued)

The project would follow a three step path:

1. **Technology**– Assess current technologies and how they could be utilized by a proliferating nation or entity.
2. **Key Properties** –The goal here would be to identify the equipment, materials, chemicals, and possibly infrastructure that may be indicative of an entity taking a path to proliferation and using laser based techniques.
3. **Signatures** – Look for any nuclear, chemical, and material morphology signatures that may be present.

Expected Impact

- Laser isotope separation methods provide a potential technology for a proliferator to produce enriched material.
- The footprint of such facilities are potentially less than what a centrifuge enrichment technology would have.
- Laser technology continues to improve and these improvements increase the ability of a proliferator to utilize laser enrichment methods.
- This work will identify the nuclear, chemical, and material morphology signatures that may be utilized to change the isotopic composition of materials.

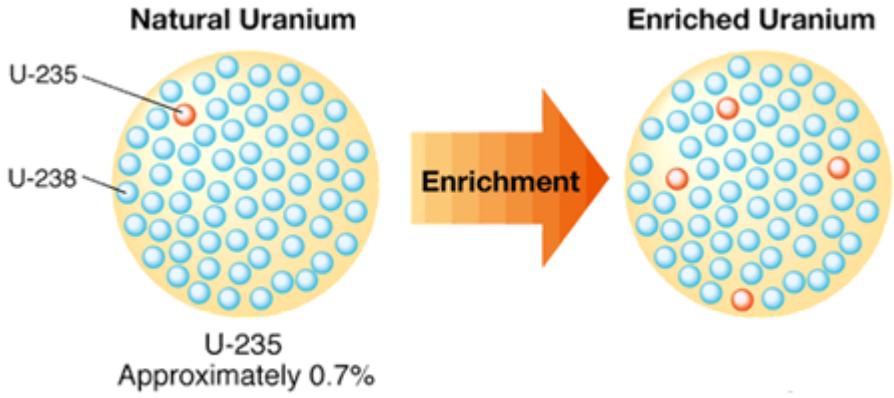


AVLIS at LLNL

https://en.wikipedia.org/wiki/Atomic_vapor_laser_isotope_separation

MTV Impact

- This project aims to be in collaboration with Lawrence Livermore National Laboratory.
- Personnel transitions: Plans for future relationship with national labs.
- Multiple students (graduate and undergraduate) will contribute to this research and align with national laboratory partners.
- This work will develop unique signatures to be utilized by the nation and international monitoring community.



Conclusion

- This work is a component of Thrust Area 2: Signals and Source Terms for Nuclear Nonproliferation.
- Developments under this research will aid in the detection of the use of laser enrichment methods by a potential proliferating nation.

Acknowledgements

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