The Proliferation Risks of Laser Isotope Separation Technology

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Introduction

• Uranium enrichment has proven to be a far more discreet route to nuclear weapons than the production of plutonium

• Enrichment by Laser Isotope Separation (LIS) once thought too complex for potential proliferators

• Technological development has since made it a far more pressing proliferation risk

• Novel attempts to mitigate these risks may have side effects for nuclear innovation
Laser Isotope Separation Techniques

• **Atomic Vapour Separation (AVLIS)**
  - Tuned laser creates electric charge in U-235 atoms
  - Charged U-235 atoms removed electromagnetically
  - Feedstock: Pure uranium metal ingots
  - Laser energy required: ~6.2 eV

• **Molecular Separation (MLIS)**
  - Tuned lasers ‘break’ molecules of 235UF6, leaving undesired molecules intact
  - Fragments of 235UF6 removed chemically
  - Feedstock: Uranium Hexafluoride (UF6)
  - Laser energy required: ~4-5 eV
  - **SILEX**
  - Highly confidential variant of MLIS – affects 235UF6 molecules, but does not break them.
  - Requires lower laser energy: <4 eV

Images courtesy of Los Alamos National Laboratory
Proliferation Risks

• **Declared Laser Isotope Separation plants present a small risk**
  
  IAEA has experience monitoring UF6 flows (MLIS & SILEX), but less practice monitoring atomic vapour flows (AVLIS). Unfamiliar techniques could complicate monitoring procedures.

• **The development of a covert, undeclared laser enrichment programme is a far greater risk**
  
  • At least 27 states have explored laser enrichment, making relevant expertise widespread
  
  • Efficiency allows a small-scale project, with low material input, to produce significant quantities of HEU
  
  • Characteristics of laser enrichment R&D, and ultimately proliferation-scale laser enrichment plants themselves, make detection through traditional
Covert Laser Enrichment R&D Pathway

(credit to Denys Rousseau et al., IAEA-CN-184/262)

1. **Spectroscopy**
   - Develop understanding of laser-uranium interaction
   - In particular, transitions to and lifetimes of, excited uranium states

2. **Laser Technology Development**
   - Selection, acquisition, and testing of laser system

3. **Material Processing Development**
   - Develop methods of generating appropriate uranium feed, waste, and product streams
   - AVLIS: Atomic vapours
   - MLIS/SILEX: UF6

4. **System Integration**
   - Integrating laser and material processing technologies
   - Developing cascade structures
   - Testing and commissioning
Traditional Detection Mechanisms

**Uranium**
- IAEA CSA and the Additional Protocol
- Export Controls

**Equipment**
- IAEA Additional Protocol
- Export Controls (NSG)

**Expertise**
- IAEA Additional Protocol
- OSINT
- HUMINT

**Facility**
- IAEA Additional Protocol (Satellite imagery & declarations)
- HUMINT
Barriers to Detection

1. **Spectroscopy**
   - Very little uranium required (<1kgee)
   - Does not require control

2. **Laser Technology Development**
   - Requires no nuclear materials
   - NSG lists cover a range of controlled methods

   • No stage is unique to the separation of fissile isotopes (dual-use)
   • Each stage can be carried out in different locations
   • A final integrated system produces a very small footprint
   • *In theory*, an advanced programme could produce a bomb’s worth of HEU from <1kgee of depleted uranium

   Depleted uranium & depleted UF6 can be used
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Mitigating the Risks of Laser Isotope Separation Technology

Strengthen IAEA monitoring and require more rigorous export control

- Universal adoption of the Additional Protocol
- Rigorous implementation of export controls
  - Feasible?

Increased reliance on HUMINT and OSINT

- S. A. Erickson from LLNL:
  ‘An alternative, though more labour-intensive, source of clues would be monitoring training, work experience and scientific interchange of nationals of a possible proliferating nation’.

- Increased reliance on the monitoring of individuals could stifle scientific exchange and interaction?

Discourage pursuit of laser isotope separation

- US State Department Proliferation Assessment of SILEX plant:
  ‘It seems likely that success with SILEX would renew interest in laser enrichment by [...] proliferants’

- Consider this risk before licensing SILEX plant?
- Fair? Deny licensing because a technology is effective?
- Effective? GE-Hitachi obviously think it is worth investing in
Thank you for listening!

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