Krypton Fluoride Laser Driven Inertial Fusion Energy

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NAS Committee on the Prospects for Inertial Confinement Fusion Energy Systems
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presented by
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Fusion Energy with Lasers and Direct Drive

- Target factory
- Target
- Tritium breeding
- Electricity or Hydrogen Generator
- Laser Array
- Final optics
- Reaction chamber
Why we believe direct drive with lasers can lead to an attractive power plant

1. Simplest target physics:
2. Laser (most costly component) is modular
3. Separate components lower cost of development
4. Simple spherical targets: facilitates mass produced "fuel"
5. Power plant studies economically attractive
6. We have made a lot of progress!!
What is a Krypton Fluoride (KrF) Laser?

- Gas Laser—Excimer (Excited Dimer)

- Fundamental wavelength is 248 nm
  - $\text{Energy} + (\text{Kr} + \text{F}_2) \rightarrow (\text{KrF})^* + \text{F} \rightarrow \text{Kr} + \text{F}_2 + h\nu$ $(\lambda = 248 \text{ nm})$

- Small discharge pumped KrF lasers are used routinely in industry for chip lithography

- Large KrF lasers for IFE are pumped with electron beams
  - Share several technologies with commercial systems
  - Requires R&D for e-beam science & technology and larger size

Cymer ELS 7010
KrF lasers have inherent advantages for fusion energy

**PHYSICS: High Gain**

- Most uniform laser beam
  
  Helps achieve smooth implosions

- Shortest UV (248 vs 351 nm)
  
  Allows higher drive pressures
  Better coupling to target
  Higher threshold for Instabilities

- "Zoom" (decrease spot as pellet implodes)

**POWER PLANT: Attractive Technology**

- Gas Medium...easy to cool, durable

- Mostly robust industrial technology
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NRL agrees with
The ICF community common viewpoint

• Demonstration of laboratory ignition will establish that the physics underpinning IFE exploitation is fundamentally sound.
• IFE is a field in which the US is a clear world leader – academically, technologically and industrially.
• We have an opportunity to capitalize on this leadership position over the next few years, and leverage prior substantial defense program investment.
• Recent action by the DOE to propose a new IFE development program and secure a stable home for IFE is timely and very welcome.
• Moving forward, the IFE program needs to focus on the requirements of an operating power plant, with design choices managed at a systems-level.
• The inherent modularity and separability of IFE provides significant benefits when considering power plant development, operations, and evolution.
• Taking advantage of significant prior research, future development activities in this program need to include IFE scale science and technology development and demonstration.
• IFE is a national scale program requiring a coordinated effort by academic, Laboratory, and industrial partners.
• A phased program with competition and unambiguous selection criteria is needed