ID: IFE/P4-17

Conceptual Design of Laser Fusion Subcritical Research Reactor with J-EPoCH Facility for Fusion Engineering Research

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ABSTRACT

- The laser fusion subcritical research reactor, the newly named Laser-fusion Subcritical Power Reactor Engineering Method (L-Supreme), is conceptually designed.
- The combination of the Japan establishment for Power-laser community Harvest (J-EPoCH) with ~10 kJ at the maximum rate of 100 Hz and a Large High Aspect Ratio Target (LHART) has the potential to create a point neutron source of 10^{13} n/shot.
- $Li_{17}Pb_{83}$ and B_4C have high ability in neutron - thermal (n-t) conversion. The cores with an 80 cm thickness will recover more than 89 % of the DT fusion neutron energy. L-Supreme will generate 21.4 W of the thermal fusion power with the $Li_{17}Pb_{83}$ core (an 80 cm layer thickness) at 1 Hz operation.

BACKGROUND

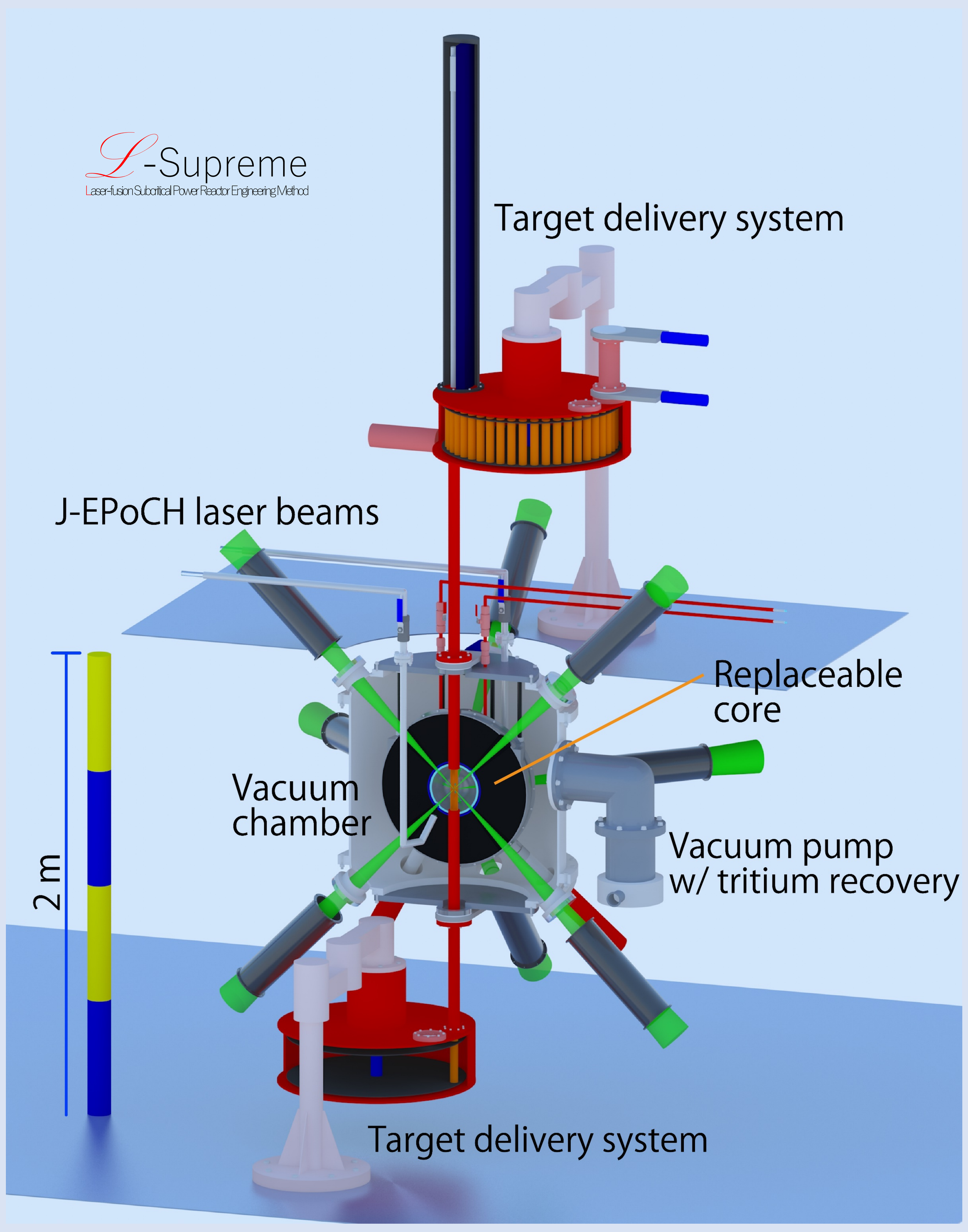
- To date, fusion power has never been generated. The first fusion power demonstration in principle must be impressive, and proof experiments should reveal a lot of remaining issues to realize fusion power plants.
- LHART has demonstrated to yield 10^{13} neutrons with Gekko XII in ILE [1].
- The ability of the laser fusion subcritical research reactor has been discussed with a fixed core size [2]. The subcritical research reactor can convert 10^{13} neutrons per shot into the thermal energy of 14 J with a B_4C core and can yield 9.1×10^{11} tritium (T) per shot with a LiPb core.

Laser-fusion Subcritical Power Reactor Engineering Method, L-Supreme

SYSTEM CONFIGURATION

L-Supreme includes a dedicated target chamber, a target delivery system, a hollow sphere core and a vacuum system with tritium recovery, except for the laser system. The core is replaceable to conduct various fusion engineering experiments. Existing technologies would realize each system.

Each LHART is contained in a capsule, which is delivered at the center of the core shot by shot. A linear motor driven system can deliver the capsules at the repetition of more than 1 Hz.



Conceptual drawing of L-Supreme

CALCULATION MODEL

CORE DESIGN

In order to achieve the first laser fusion power generation in principle, n-t conversion rates from several core materials are estimated.

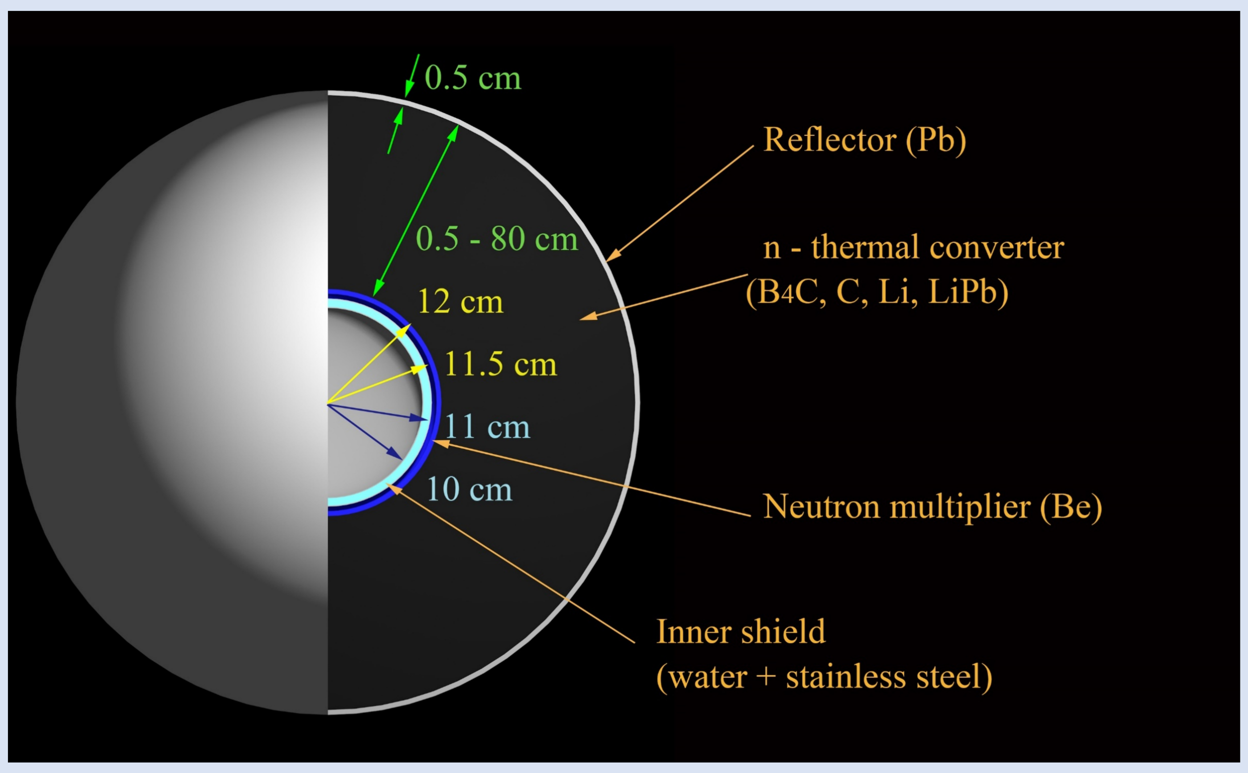
PHITS

The Particle and Heavy Ion Transport code System (PHITS) [3] is used to calculate the energy deposit in cores.

CORES

Boron carbide (B_4C), graphite (C), lithium (Li), and lead-lithium alloy ($Li_{17}Pb_{83}$) are selected as n-t conversion materials. They can compose cores as engineering products.

The inner shield prevents n-t conversion from being affected by the energy of debris and laser beams. The inner shield consists of a stainless-steel shell with water cooling pipes.



Core for n - t conversion

THERMAL FUSION ENERGY

- The DT fusion neutron energy is effectively converted by $Li_{17}Pb_{83}$ and B_4C. The cores with an 80 cm thickness will utilize more than 89 % of the neutron energy as the thermal fusion energy.
- The thinner n-t conversion layer becomes higher temperature rise. Not only the total energy deposit but also the heat capacity of the layers affect the temperature rise.

Thermal fusion energy converted with several candidate materials.

n–t conversion materials	Thermal fusion energy [J/shot]	Temperature rise [mK/shot]
Boron carbide	20.0	0.150
Graphite	18.3	0.178
Lithium	17.7	0.0879
Lead-lithium alloy	21.4	0.203
Layer thickness	80 cm	5 mm

SUMMARY

- The laser fusion subcritical research reactor, L-Supreme, with the J-EPoCH facility has been designed conceptually.
- The thermal fusion power of 21.4 W will be generated in the $Li_{17}Pb_{83}$ core at 1 Hz laser operation.
- Temperature will rise 0.203 mK/shot in the 5 mm $Li_{17}Pb_{83}$ n-t conversion layer. It can be detectable by conventional measurement techniques.

ACKNOWLEDGEMENTS / REFERENCES

This work is performed with the support and under the auspices of the NIFS Collaboration Research Program (NIFS21KUGK139).

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