# Concept of Using Alternative Inertial Fusion Fuel

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EXECUTIVE SUMMARY

IFE (inertial fusion energy) development is extremely challenging as the most powerful laser drivers still yet to produce the goal of ignition. One area worth to investigate is unconventional fuel type with initial density an order of magnitude higher, which could significantly increase the plasma triple product by Lawson criterion of density, confinement time, and plasma temperature.

Topic Area: General, including complete IFE concepts

The fusing of light atomic nuclei – nuclear fusion – is the same reaction that has been powering the Sun and stars since their formation and could potentially be an invaluable power producing source. The Sun and similar stars produce fusion energy by gravity confinement that is not achievable on Earth. D (deuterium) -T (tritium) fusion is considered to be the easiest nuclear fusion reaction to be initiated artificially. Combining D and T through nuclear fusion reaction produces $^4$He, neutrons and enormous energy. The minimum requirement for fusion ignition is that the rate of the fusion energy production is higher than the rate of the energy loss to the environment, so that the system is sustained. The concept is further studied in the Lawson criterion, which provides a minimum required value for the triple product of density, confinement time, and plasma temperature in thermonuclear fusion. Confinement time is determined by design, in which magnetic confinement fusion (MCF) typically has longer confinement times than inertial confinement fusion (ICF), but ICF tends to have much higher plasma densities. Fusion requires plasma temperatures above 100 million Kelvin (~20 keV) that are achieved nowadays without difficulties. The plasma density has not been given enough considerations in the fusion energy development. It is proposed to investigate nonconventional fuels that have initial densities an order of magnitude higher than the D-T fuel. Current consideration is condensed phase fuel at ambient conditions, such as deuterium hydride, heavy water, etc. At fusion plasma temperatures all molecules are broken down into charged atoms and ions, so that hydride metal and oxygen will be liberated from the fuel. Their impact to the fusion yield and whether they enhance or hinder the fusion reaction will need to be investigated. Conventional D-T fusion has very low initial fuel density using low pressure D-T gas. Even low temperature liquid and solid hydrogen have poor density. As an example, liquid hydrogen ($H_2$) has a density of 0.07 g/cc (comparing to water at 1.0 g/cc).

**The goal is to identify a fuel with initial density an order of magnitude higher, which could increase the triple product by Lawson criterion significantly in ICF plasma.**