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# FUSION PROPULSION AND POWER FOR EXTRASOLAR EXPLORATION

**Abstract**

Direct Fusion Drive (DFD) is a nuclear fusion engine that produces both thrust and electric power. It employs a field reversed configuration (FRC) with an odd-parity rotating magnetic field heating system to heat the plasma to fusion temperatures. No self-heating is available since the products of the fusion reactions leave the FRC before they can transfer their energy to the reactants. This also prevents the tritium from the D-D side reactions from fusing thus reducing the neutron wall load. The engine uses deuterium and helium-3 as fuel and additional deuterium or hydrogen that is heated in the scrape-off layer for thrust augmentation. In this way variable exhaust velocity and thrust is obtained.

This paper presents the design of an engine for a mission to reach the gravitational lens beyond 550 AU, which allows the sun to act as a gravitational lens to image exoplanets in nearby star systems. This mission has unique requirements which can be met with fusion power and propulsion, including maneuvering at the lens point and potentially powering a cluster of independent sensing spacecraft to increase the aperture. Science objectives at the lens include imaging, spatially resolved spectroscopy, and secondary objectives such as studying the black hole at the center of our galaxy. With DFD, the power available for science payloads, data processing, communication, and maneuvering will be measured in megawatts. These capabilities remove constraints on the science payloads, expanding the design space. With DFD affording sufficient resolution, it may be possible to identify clusters of features like lakes on the surface of exoplanets, and even temporally resolve weather patterns. Using conventional rocket technology, the duration of the transit to 550 AU would take 30 years, and data collection would start in 2060. Using the Direct Fusion Drive (DFD), the duration of the transit to 550 AU will take about 13 years. Even accounting for development time, data collection will start 15 years earlier than with conventional technology: in 2045 rather than 2060. DFD also allows a much smaller launch vehicle to be used, reducing mission costs substantially.

The paper includes an updated design of the Direct Fusion Drive engine with the latest results from our recently completed NASA NIAC Phase II study. The design of a closed-loop non-thrusting mode is discussed, which will extend the duration of the mission at the lens.