Direct Fusion Drive

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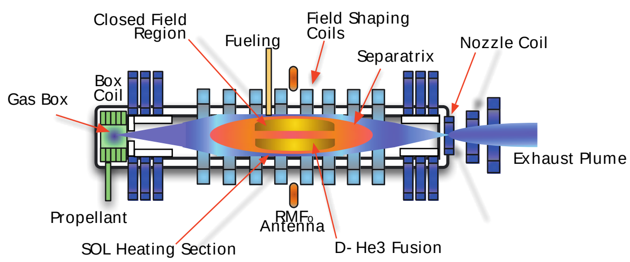
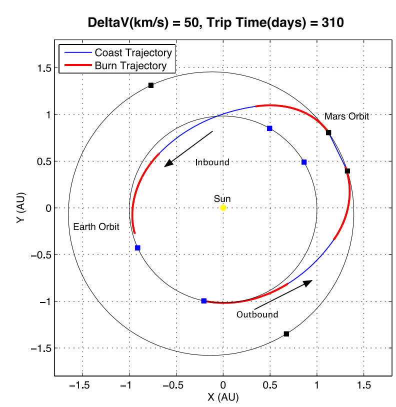
The Direct Fusion Drive (DFD) is a nuclear fusion engine that produces both thrust and electric power. It employs a field-reversed configuration (FRC) to confine plasma and a novel radio-frequency plasma heating system to enable 1 to 10 MW fusion reactors with low neutron emissions. The FRC has a relatively simple linear magnet configuration with significantly higher plasma pressures than other magnetic fusion reactor designs. The reactor is ideal for space propulsion as it produces both propulsion and power in a compact package. The engine uses deuterium and helium-3 as fuel; additional deuterium is injected into the FRC's scrape-off layer, heated by fusion products for thrust augmentation, thus controlling exhaust velocity and thrust.



The DFD is linear with propellant exiting through a magnetic nozzle. PFRC-2 experiments are ongoing at PPPL.

DFD provides game-changing levels of power and thrust for interplanetary missions and high power/delta-V missions in Earth orbit, such as military lasers. We provide an overview of mission studies performed using DFD as an enabling technology, including: human missions to Mars, Jupiter icy moon missions, interstellar robotic missions, and asteroid deflection. Thrust levels are high enough that transfer to Mars can be done with two burns and a coasting period in between. For example, the 310-day Mars mission at right includes 4 burns between 300 and 400 N with an exhaust velocity near 100 km/s. We will present sample trajectories for these missions generated by simulation. The presentation will include a DFD engine design for a Mars-orbital mission, complete with specific power and mass budget for the engine.



We also discuss the development plan for DFD. The current hydrogen PFRC-2 device operating at the Princeton Plasma Physics Laboratory focuses on ion heating and confinement experiments. PFRC-3 is planned to demonstrate higher temperatures and pressures by 2019 and PFRC-4 would demonstrate D-^{3}He fusion by 2023. We project that a terrestrial test engine could be in operation within 12 years at a cost of $78M USD, comparable to the cost of a single Radioisotope Thermoelectric Generator (RTG).