

Direct Fusion Drive for Interstellar Exploration

Samuel Cohen¹, Charles Swanson¹, Gary Pajer², Stephanie Thomas² and Michael Paluszek^{2*}

¹ Princeton Plasma Physics Laboratory, Princeton, NJ 08544 USA

² Princeton Satellite Systems, 6 Market Street, Suite 926, Plainsboro, NJ 08536, USA

Abstract

The Direct Fusion Drive, based on the Princeton Plasma Physics Laboratory's Princeton Field Reversed Configuration machine, has the potential to propel spacecraft to explore interstellar space and nearby solar systems. This paper discusses a design for a starship that would be applicable to a wide variety of interstellar missions. Direct Fusion Drive employs a unique plasma heating system that produces nuclear fusion engines in the range of 1 to 10 MW that is ideal for human solar system exploration, robotic solar system missions and interstellar missions. This paper first gives an overview of the physics of the engine; the fuel selection is explained and the innovative heating system is discussed. The thrust augmentation system is explained along with new results of the UEDGE multifluid code simulations giving an envelope of expected thrust and specific impulse. The power balance is shown and the subsystems needed to support the fusion reaction are discussed. The paper gives the latest results for the system design of the engine including work done under a NASA NIAC study just completed. A mass budget is presented for all of the subsystems with explanations of the analysis used to generate the masses. The paper then discusses potential interstellar missions. The first are flyby missions. One is the 550 AU mission which will use the Sun as a gravitational lens for use in exoplanet research. This mission can be done without a deceleration phase. Next, flyby missions to the nearest star are shown. Finally we discuss a mission to go into orbit about a planet orbiting either Alpha Centauri A or Alpha Centauri B. The mission analyses include a communications system link budget. DFD can operate in electric power only mode allowing nearly the full propulsion power to be used for the payload and communications. This greatly enhances the scientific return. All of the missions start in low earth orbit for spacecraft checkout and testing. The small amount of fuel and 21 day duration of a spiral Earth escape is shown to result in significant mission cost savings.

Keywords: Interstellar, Gravity Lens, 550 AU, Alpha-Centauri, Nuclear Fusion

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