Neutron Engine

We have plans and intellectual property on fusion powered rockets. When Apollo went to the moon, it's rocket burned at about 9 g's of acceleration for approximately 10 minutes to push it out of Earth orbit. The craft coasted to the Moon decelerating until reaching the equal gravitational point between the Earth and the Moon. Once under Lunar gravitational pull, the craft then accelerated to the Moon. At the proper point, its engine re ignited, decelerating the craft into Lunar orbit. This trip took about 3 days, 76 hours. It is not possible to carry sufficient fuel for chemical rockets to continuously operate all the way to the Moon.

Fusion rocket engines could continuously power a craft to the moon with less than a pound, rather than tons, of fuel allowing constant rate of 1g acceleration and deceleration to the Moon. Such a trip would take only about 4 hours. A trip to Mars would take about 2 days rather than 80 to 333 days. A trip to Pluto in would take about 16 days rather than about 10 years. Constant 1g acceleration and deceleration allow destination arrival at orbital velocity and then subsequent return to Earth.

Fuel consumption for a constant 1g acceleration and deceleration flight depends on the mass of the craft. A 1 MW reactor with 1,000# thrust will propel 1000# for about 1042 days or 2.8 years with 1# of fusion fuel. A 15 MW reactor with 15,000# thrust will propel 15,000# (about the weight of the Apollo Command Module) for about 70 days with 1# of fusion fuel. A 50 MW reactor with 50,000# thrust will propel 50,000# (about 20 tons) for about 20.8 days with 1# fusion fuel. A 300 MW reactor with 300,000# thrust will propel 300,000# (approximately the mass of the space shuttle) for about 3.5 days with 1# of fusion fuel.

The only existing alternatives are gravity assist and ion engines. With gravity assist, the craft must be launched within critical time periods for planetary alignment. For the craft to orbit a planet it must carry sufficient chemical propellant for orbital deceleration. Presently outer Solar System trips using these gravity assist and ion engines result in approach velocities too high to enter into orbit, permitting only a fast flyby with no opportunity to return to Earth.

Ion engines have been in development since the 1960's. They require very large amounts of electricity for proportionality very small amounts of thrust. NASA's X3 thruster, see below, requires 102kW of electricity, most likely provided by a heavy thermal nuclear decay source, for only 1.2 pounds of thrust.

Heavy lift chemical rockets get you to orbit, but are inappropriate for fast Solar System flight. A larger version of our proposed POC reactor can be modified to produce 372 pounds of thrust with 10-20kW DC power output from waste heat using off the shelf parts for the reactor core. It is estimated to be 36" diameter, 96" long, with 2-4 tons of mass. A similarly sized phase II reactor variant (having a virtual target) would produce approximately 50,000 pounds of thrust. Advanced reactors promise very heavy lift (1 M # of thrust) long running Solar System spaceflight engines impossible with chemical propulsion. A high vacuum environment is not needed for operation making development simpler, cheaper, and allowing landing on bodies without atmospheres. Continuous running, high thrust, low specific fuel consumption engines will change all the dynamic parameters of Solar System spaceflight. Proposed specifications compared with NASA's X3 thruster follow.

NASA X3 Thruster.

36" diameter, 500 pounds of mass just for the thruster, not including 102kW power supply and accessories.
Maximum thrust 1.21 pounds or 5.4 Newtons for 1.44kW power output.
84kW drive power required per pound of thrust output.
102kW drive power for maximum thrust of 1.21 pounds or 5.4 Newtons output.
Efficiency at max power 1.41%.

Proposed FESH 372 kW Neutron Engine.

36" diameter, 96" long, 2-4 tons of mass for a complete package.
Maximum thrust 372 pounds or 1395 Newtons for 372kW power output.
7.1 e^{17} neutrons per second ejection at about 10.4 MeV near the speed of light.

Fuel consumption. One pound of fuel operates for 67,794 hours, 2,821days, 7.7 years.
Fuel: Presently 50% Deuterium and 50% Tritium. Research likely will make 100% Deuterium fuel possible. Neutrons will then be at about 2.45 MeV near the speed of light.

Electric drive requirements.
Less than 1 watt drive power to power the reactor at full output of 372kW.
Less than 1.2 e^{-2} watts drive power per pound of thrust output.
Total system power requirement at full output less than 400 watts.
Efficiency at maximum thrust greater than 93,000%. Power gain due to fusion reactions.
System able to thermoelectrically generate 10-20kW DC while producing full thrust.
Above estimate was using "off the shelf" parts for the reactor shell.

On success of our reactors, it's possible to make a 1,000 pound thrust unit with no more than 4 tons of mass for complete package. More advanced technologies will make the 1000 pounds of thrust seem small. Large thrust growth potential with this technology. Half a million pounds of thrust and larger are possible. Does not need a vacuum environment for operation or testing. One kW power of reactor power output equals 0.84 pounds or 4.45 Newtons of thrust.

Proposed FESH High Thrust, Long Haul Engines.

After the above specifications were drafted, Dr. DeLuze looked into further ramifications of spaceflight with 1 g acceleration. The movie "Journey To The Pale Red Dot" postulated spaceflight to Alpha Centauri the Sun's closest neighbor 4.37 light-years away. An approach using laser sails comprising less than 2 grams of mass was proposed. An array of high powered laser telescopes on Earth would push these sails taking about 21 years for them to arrive. Their speed at arrival would be about 20% of the speed of light leaving only minutes to observe this star and its orbiting planet. A very exotic, high cost trip for relatively limited information. What about sending a probe weighing tons into parking orbit about the this star and its planet with capability to return to Earth?

This question reveals profound importance of the proposed FESH neutron engines. A craft accelerating from Earth orbit at constant 1 g acceleration and deceleration will enter orbit of Alpha Centauri in about 6.00 years, with Spacecraft time about 3.52 years. Maximum speed will be about 95.2% of the speed of light with the craft arriving at stellar orbital velocity. The FESH engine proposes an estimated specific fuel consumption of 4.0 E^{-5} pounds (1.81 E^{-2} grams) of fusion fuel per hour per 1000 pounds of thrust. A 50 ton spacecraft of which about 5 tons comprises the engine will use no more than 250 pounds of fuel for a one way trip. 500 pounds is adequate for a round trip. A 500 ton spacecraft, with the space shuttle being about 125 tons for comparison, would consume no more than 2.5 tons of fuel for a round trip. The engine system would not exceed 50 tons including fuel. Transient times and speeds are the same for both.

The specific fuel consumption approximations demonstrate exceedingly low magnitude. In the event that development results in specific fuel consumptions a magnitude of order greater, such performance would still be extraordinary. Consider the case of a one way transient with the 50 ton craft, the fusion engine usage is 0.125 tons of fuel compared with 1968 tons used by chemical propulsion. This difference exceeds four orders of magnitude.

Patent Applications.

FESH is ready for to file patent applications to secure intellectual priority on this art. There is a previous expired US patent application for such an engine. Dr. DeLuze is prepared to file a new patent application naming this older patent as prior art, reestablishing intellectual priority for this art. The older application disclosed a cylinder and claimed deuterium fusion reactions therein with all generated neutrons exiting the cylinder at just one end. This established a process patent of a neutron engine without disclosing the internal means by which such processes operate. The new application will disclose these process means within the cylinder for creating controlled, efficient fusion reactions and for directing the radiated neutrons out just one end of the cylinder. It will disclose these means to a level of detail from which prototype construction plans can be prepared. At this stage of development of this art there will likely be changes and improvements made which can then be covered with continuation in part applications on the original parent application.