An Extremely High I_{sp} Spacecraft Propulsion System

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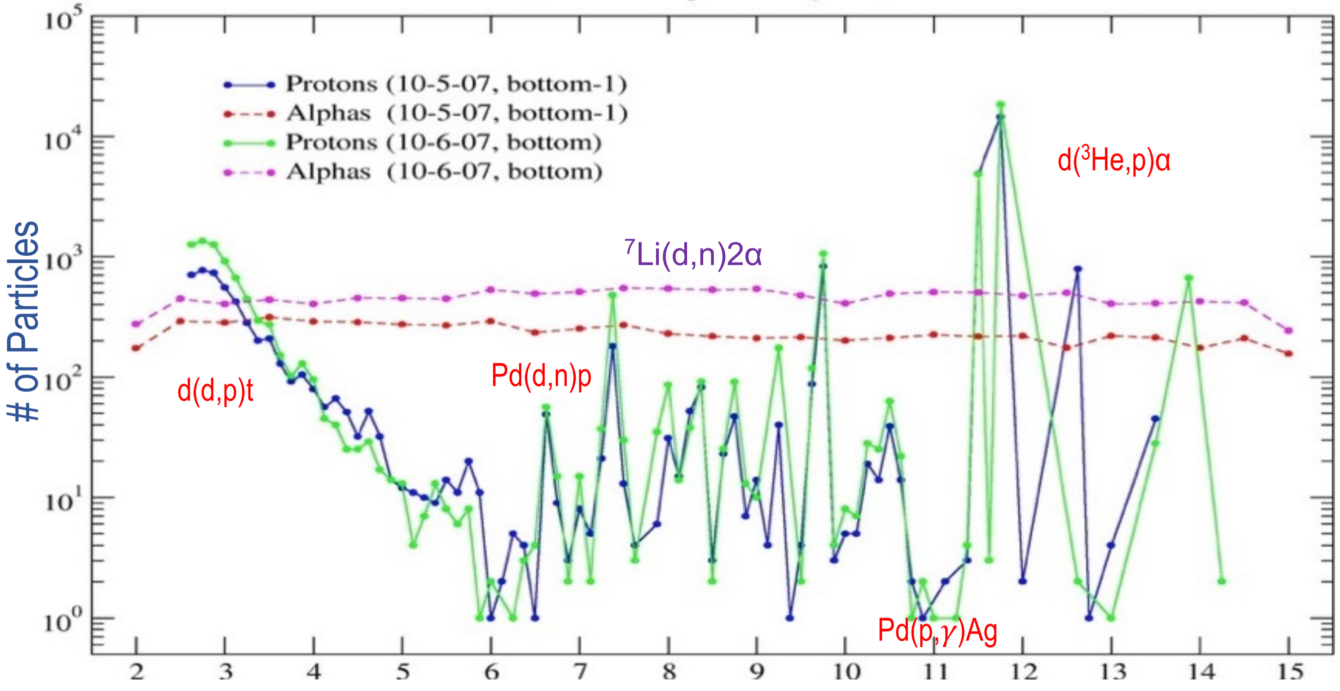
Lattice Confinement Fusion (LCF)[1]

Protons and Alpha Particles



Measured Nuclear Reactions:

NASA JSC Linear Energy Transfer Analysis of Solid State Nuclear Track Detectors (CR-39) from two experiments[2,3] at SRI.

e.g.

^{7}Li(d,n)2α 3-body nuclear reaction

Proposed Application:

Lattice Confinement Fusion reaction charged products for high I_{sp} propulsion:

- D($^3He,p$)α > 14.8 MeV proton, 3.4 MeV α
- Pd(d,n)p > 6 MeV proton
- ^{7}Li(p,α)α > two 8.5 MeV α

LCF: Triggered fusion in electron-screened, high-density deuterated metal lattices.

[1] Baramsai, et. al., "NASA's New Shortcut to Fusion Power: Lattice Confinement Fusion Eliminates Massive Magnets and Powerful Lasers", IEEE Spectrum (March, 2022). https://spectrum.ieee.org/lattice-confinement-fusion

[2] P.A. Mosier-Boss, et al., ," Detection of high energy particles using CR-39 detectors part 1: Results of microscopic examination, scanning, and LET analysis", *Int. J. of Hydrogen Energy,* **42**, 1 (2017) pp 416-428.

[3] US Patent #8,419,919, "System and Method for Generating Particles", (2013).

Specific Impulse
It's all about the exhaust velocity!

- Specific Impulse is a measure of rocket engine efficiency expressed in seconds
  - $I_{sp} = v_e/g_o$ where v_e is the propellent exhaust velocity in m/s, g_o = 9.8 m/s^2

Propulsion	Exhaust Velocity (v_e)	Specific Impulse (I_{sp})	Thrust
Chemical	$v_e < 4.4 \times 10^3$ m/s	$< 4.5 \times 10^2$ s	High
Nuclear Thermal	$v_e \approx 9.0 \times 10^3$ m/s	$\approx 9.0 \times 10^2$ s	High
Solar Electric	$v_e \approx 2.9 \times 10^4$ m/s	$\approx 3.0 \times 10^3$ s	Low
VASIMR®[1,2]	$v_e \approx 1.2 \times 10^5$ m/s	$\approx 1.2 \times 10^4$ s	Variable
Nuclear Fusion[3]	$v_e \approx 3.5 \times 10^5$ m/s	$\approx 3.5 \times 10^4$ s	High
LCF	$v_e > 1.5 \times 10^7$ m/s	$> 1.5 \times 10^6$ s	Variable

High I_{sp} usually means low thrust, but with nearly continuous acceleration!

[1] http://web.mit.edu/mars/Conference_Archives/MarsWeek04_April/Speaker_Documents/VASIMREngine-TimGlover.pdf (2004).

[2] VASIMR®: Variable Specific Magnetoplasma Rocket

[3] C.H. Williams, L. A. Dudzinski, S. K. Borowski and A. J. Juhasz, "Realizing "2001: A Space Odyssey": Piloted Spherical Torus Nuclear Fusion Propulsion", NASA/TM-2005-213559.

ANS®

An Extremely High Isp Propulsion System

- Alpha particles > 6 MeV have exhaust velocities approaching *5% speed of light!*
  - $c = 3 \times 10^8$ m/sec (speed of light in vacuum)
  - $v_e > 1.5 \times 10^7$ m/sec (propellent exhaust velocity)
  - $I_{sp} > 10^6$ sec
- ≈ 10,000 times chemical rocket I_{sp}
- ≈ 1000 times Solar Electric Propulsion (SEP) ion thruster I_{sp}
- ≈ 100 times VASIMR® I_{sp}
- Charged particles can be directed by magnetic and electric fields
- Magnetohydrodynamics (MHD) can be used to *power* the spacecraft with a loss of I_{sp}
- *LCF is an inherently low thrust system, but offers continuous acceleration like SEP*
  - Thrust can be traded off against I_{sp} by heating and expelling heavier mass

ANS®