Molten Salt Lattice Confinement Fusion (LCF) Fast Fission Reactor for Lunar and Planetary Surface Power

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Abstract. Molten salt fission reactors (MSR) have been suggested for lunar and planetary surface power systems. They have the advantage of operating at high temperature, for efficient thermal-electrical conversion, low pressure, long-lived with high nuclear fuel burnup. MSR are often designed to breed fissile ^{233}U from natural ^{232}Th by neutron capture and β decay via:

$$^{232}Th(n,\gamma)^{233}Th(\beta,\gamma)^{233}Pa(\beta,\gamma)^{233}U$$

Unfortunately, this process requires ^{233}Pa isotope separation and segregation to decay to ^{233}U. This requirement prevents additional neutron capture that interferes with ^{233}U breeding. Instead, Wooley's sub-critical, fast fission, molten salt reactor would use externally generated tokamak fusion neutrons[1,2] to fission all actinides.

We propose a simpler fusion-fast-fission sub-critical reactor that generates fast neutrons *in situ* from lattice confinement fusion (LCF) to fission fertile and fissile actinides. This hybrid reactor doesn't require enriched ^{235}U fissile pins to initiate fission reactions, nor ^{233}Pa separation and segregation during operation. Like Wooley's, this hybrid reactor "burns" natural uranium (^{238}U) or thorium (^{232}Th) which avoids uranium enrichment and additional fissile material launch safety and security costs.

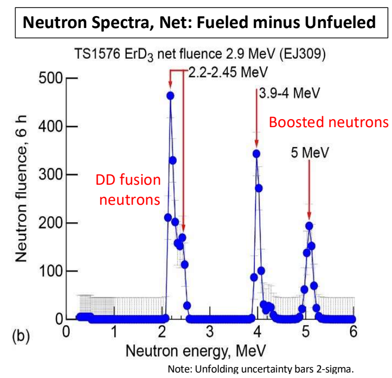

Fig. 1. Photoneutron initiated LCF

The LCF neutron source is initiated by bremsstrahlung photoneutrons (Fig. 1)[3] or isotopic neutron sources in electron-screened lattices (Fig. 2)[4,5]. Alternatively, the electrolytic Pd-deuterium co-deposition[6] protocol fast fissions[7] both ^{232}Th and ^{238}U. However, an aqueous electrolyte-based system, without pressurization similar to conventional pressurized water fission reactors, is incapable of high temperatures due to the boiling point of the electrolyte slightly over 100 °C. Molten salts can be used instead as was demonstrated at the University of Hawaii[8] using a variety of Ni and Pd cathodes in lithiated, hydrided and deuterated salts.

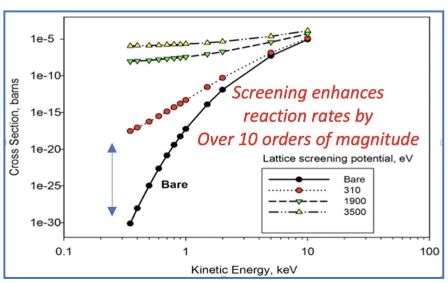

Fig. 2. Electron screening enabled LCF

These salts have melting points often exceeding 500°C making them suitable to efficiently produce electrical power[9] through either Advanced Stirling Generators (< 100 kWe) or closed-Brayton Cycle (> 100 kWe). This hybrid reactor could power a wide range of lunar or Martian applications from unmanned instruments, to charging vehicles and entire facilities such as human habitats or *in situ* resource utilization. The power conversion cycles are Carnot Cycle limited, but generally 30% efficient at best. However, waste heat on the moon or Mars is important to surviving either two-week lunar nights or Martian nights as well as providing process heat for mineral extraction and "living off the land".

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