Lattice Confinement Fusion

NASA Detects Lattice Confinement Fusion

A team of NASA researchers seeking a new energy source for deep-space exploration missions, recently revealed a method for triggering nuclear fusion in the space between the atoms of a metal solid.

Their research was published in two peer-reviewed papers in the top journal in the field, Physical Review C, Volume 101 (April, 2020): "Nuclear fusion reactions in deuterated metals" and "Novel nuclear reactions observed in bremsstrahlung-irradiated deuterated metals."

Nuclear fusion is a process that produces energy when two nuclei join to form a heavier nucleus. "Scientists are interested in fusion, because it could generate enormous amounts of energy without creating long-lasting radioactive byproducts," said Theresa Benyo, Ph.D., of NASA's Glenn Research Center. "However, conventional fusion reactions are difficult to achieve and sustain because they rely on temperatures so extreme to overcome the strong electrostatic repulsion between positively charged nuclei that the process has been impractical."

Called Lattice Confinement Fusion, the method NASA revealed accomplishes fusion reactions with the fuel (deuterium, a widely available non-radioactive hydrogen isotope composed of a proton, neutron, and electron, and denoted "D") confined in the space between the atoms of a metal solid. In previous fusion research such as inertial confinement fusion, fuel (such as deuterium/tritium) is compressed to extremely high levels but for only a short, nano-second period of time, when fusion can occur. In magnetic confinement fusion, the fuel is heated in a plasma to temperatures much higher than those at the center of the Sun. In the new method, conditions sufficient for fusion are created in the confines of the metal lattice that is held at ambient temperature. While the metal lattice, loaded with deuterium fuel, may initially appear to be at room temperature, the new method creates an energetic environment inside the lattice where individual atoms achieve equivalent fusion-level kinetic energies.

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Photograph of the deuterated metals exposed to the bremsstrahlung radiation during the test. During exposure, the deuterated erbium (ErD_3) showed evidence of fusion reactions.

A metal such as erbium is “deuterated” or loaded with deuterium atoms, “deuterons,” packing the fuel a billion times denser than in magnetic confinement (tokamak) fusion reactors. In the new method, a neutron source “heats” or accelerates deuterons sufficiently such that when colliding with a neighboring deuteron it causes D-D fusion reactions. In the current experiments, the neutrons were created through photodissociation of deuterons via exposure to 2.9+MeV gamma (energetic X-ray) beam. Upon irradiation, some of the fuel deuterons dissociate resulting in both the needed energetic neutrons and protons. In addition to measuring fusion reaction neutrons, the Glenn Team also observed the production of even more energetic neutrons which is evidence of boosted fusion reactions or screened Oppenheimer-Phillips (O-P) nuclear stripping reactions with the metal lattice atoms. Either reaction opens a path to process scaling.

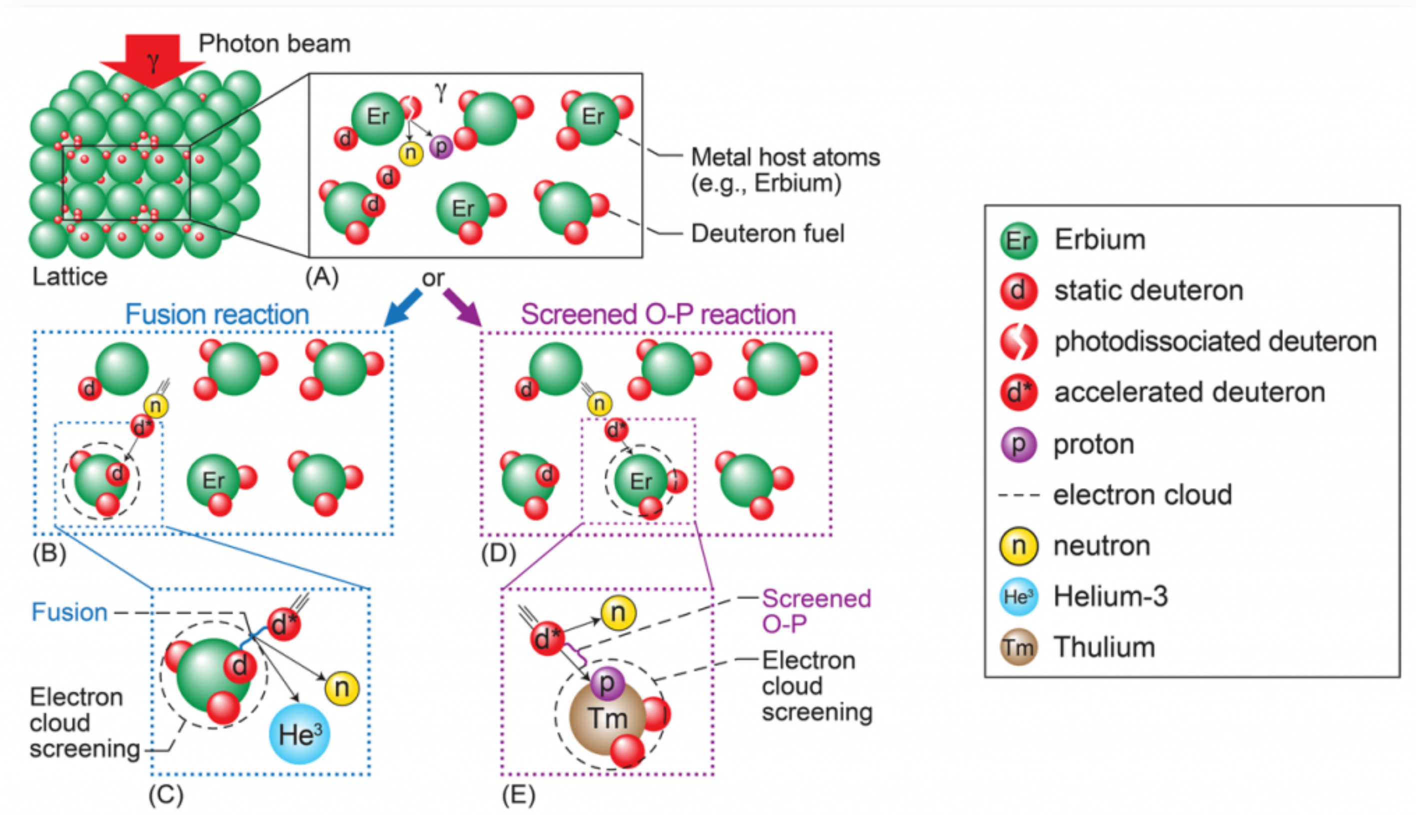

Illustration of the main elements of the lattice confinement fusion process observed. In Part (A), a lattice of erbium is loaded with deuterium atoms (i.e., erbium deuteride), which exist here as deuterons. U[...]th a photon beam, a deuteron dissociates, and the neutron

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and proton are ejected. The ejected neutron collides with another deuteron, accelerating it as an energetic “d*” as seen in (B) and (D). The “d*” induces either screened fusion (C) or screened Oppenheimer-Phillips (O-P) stripping reactions (E). In (C), the energetic “d*” collides with a static deuteron “d” in the lattice, and they fuse together. This fusion reaction releases either a neutron and helium-3 (shown) or a proton and tritium. These fusion products may also react in subsequent nuclear reactions, releasing more energy. In (E), a proton is stripped from an energetic “d*” and is captured by an erbium (Er) atom, which is then converted to a different element, thulium (Tm). If the neutron instead is captured by Er, a new isotope of Er is formed (not shown).

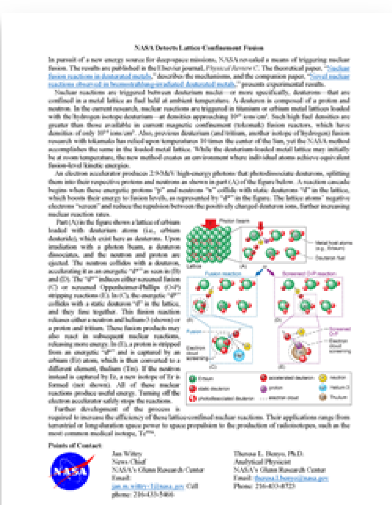
A novel feature of the new process is the critical role played by metal lattice electrons whose negative charges help “screen” the positively charged deuterons. Such screening allows adjacent fuel nuclei to approach one another more closely, reducing the chance they simply scatter off one another, and increasing the likelihood that they tunnel through the electrostatic barrier promoting fusion. This is according to the theory developed by the project’s theoretical physicist, Vladimir Pines, Ph.D, of PineSci.

“The current findings open a new path for initiating fusion reactions for further study within the scientific community. However, the reaction rates need to be increased substantially to achieve appreciable power levels, which may be possible utilizing various reaction multiplication methods under consideration,” said Glenn’s Bruce Steinetz, Ph.D., the NASA project principal investigator.

“The key to this discovery has been the talented, multi-disciplinary team that NASA Glenn assembled to investigate temperature anomalies and material transmutations that had been observed with highly deuterated metals,” said Leonard Dudzinski, Chief Technologist for Planetary Science, who supported the research. “We will need that approach to solve significant engineering challenges before a practical application can be designed.”

With more study and development, future applications could include power systems for long-duration space exploration missions or in-space propulsion. It also could be used on Earth for electrical power or creating medical isotopes for nuclear medicine.

Publications



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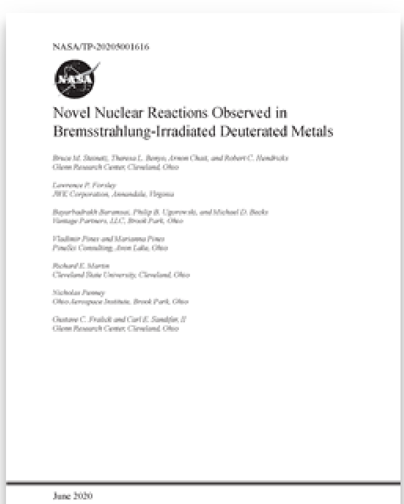

NASA/TP-20205001616

Novel Nuclear Reactions Observed in Bremsstrahlung-Irradiated Deuterated Metals

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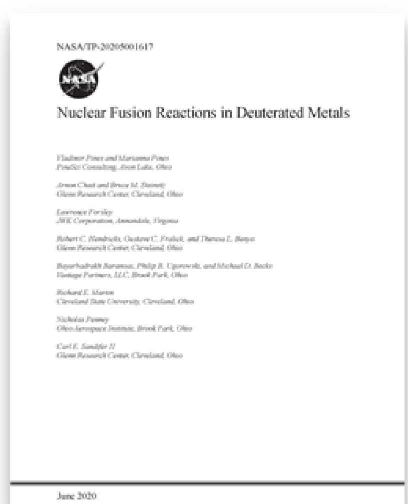

NASA/TP-20205001617

Nuclear Fusion Reactions in Deuterated Metals

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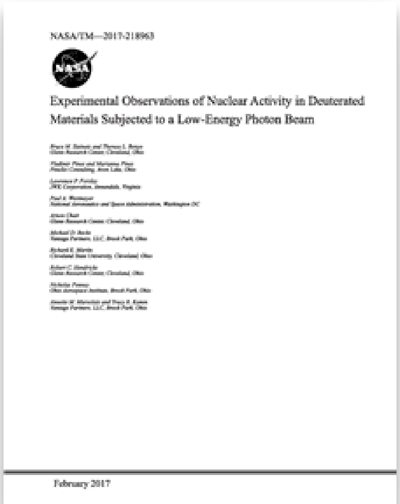
Nuclear Fusion Reactions in Deuterated Metals

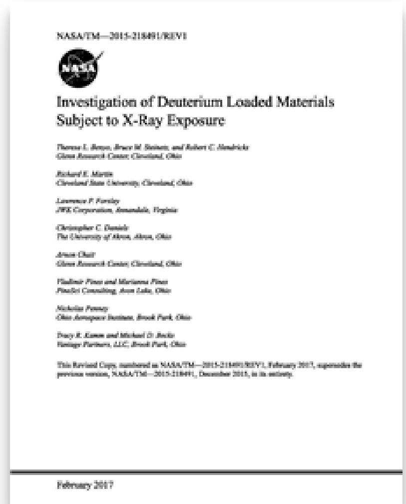

NASA/TM—2017-218963

Experimental Observations of Nuclear Activity in Deuterated Materials Subjected to a Low-Energy Photon Beam

February 2017

Experimental Observations of Nuclear Activity in Deuterated Materials Subjected to a Low-Energy Photon Beam

Gamma Energy Evaluation for Creation of Cd-111(sub m), In-113(sub m), and In-115(sub m) Isotopes


NASA/TM—2015-218491/REV1

Investigation of Deuterium Loaded Materials Subject to X-Ray Exposure

February 2017

Investigation of Deuterium Loaded Materials Subject to X-Ray Exposure

NASA GRC Hosts Lattice Confinement Fusion Virtual Workshop

Lattice Confinement Fusion (LCF) Overview

Images

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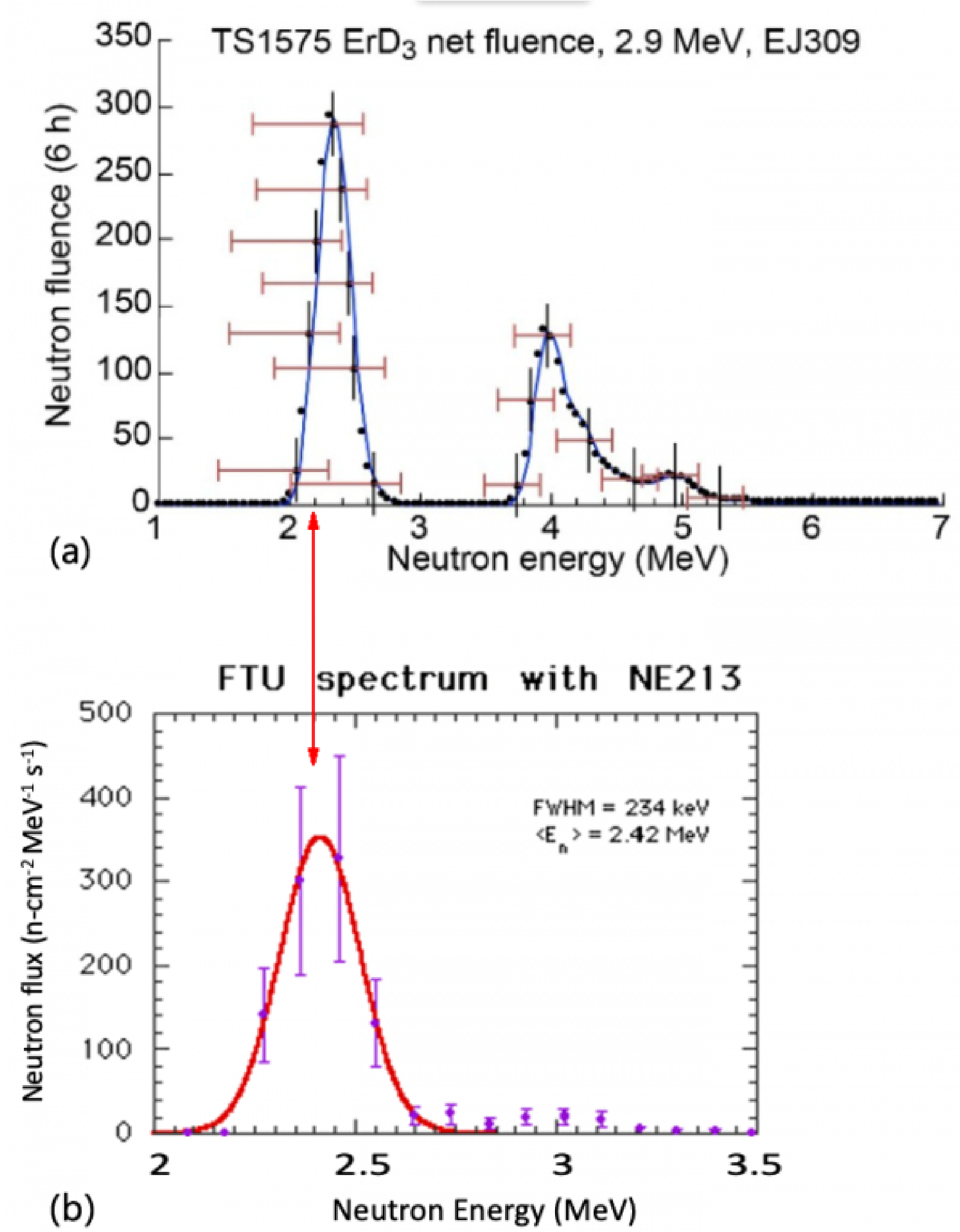

Fusion reaction results from one of the tests performed. (a) Neutron spectra observed during the gamma exposure of deuterated erbium (ErD3) showing evidence of fusion energy neutrons (~2.5 MeV). The plot also shows the presence of higher energy 4-5 MeV neutrons that indicates other nuclear processes occurred. These are believed to be screened Oppenheimer-Phillips reactions that may point a way toward increasing reaction rates, important to future applications. (b) Data from the current NASA work is consistent with fusion energy neutrons observed in an ENEA-Fusion tokamak magnetic confinement fusion reactor, shown in the lower figure.

Videos

The GRC Team's LCF Journey

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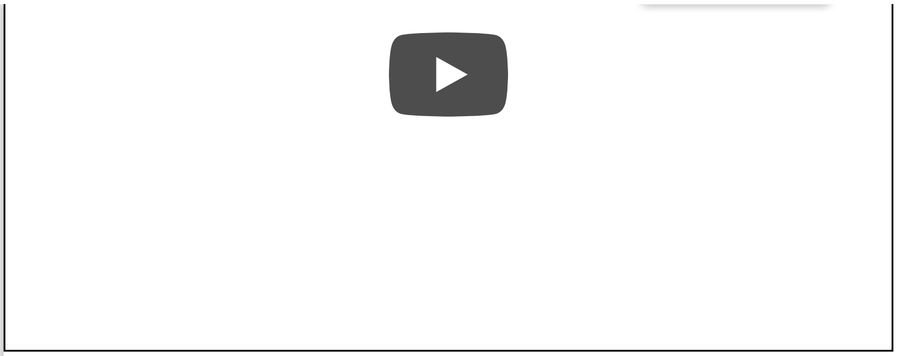
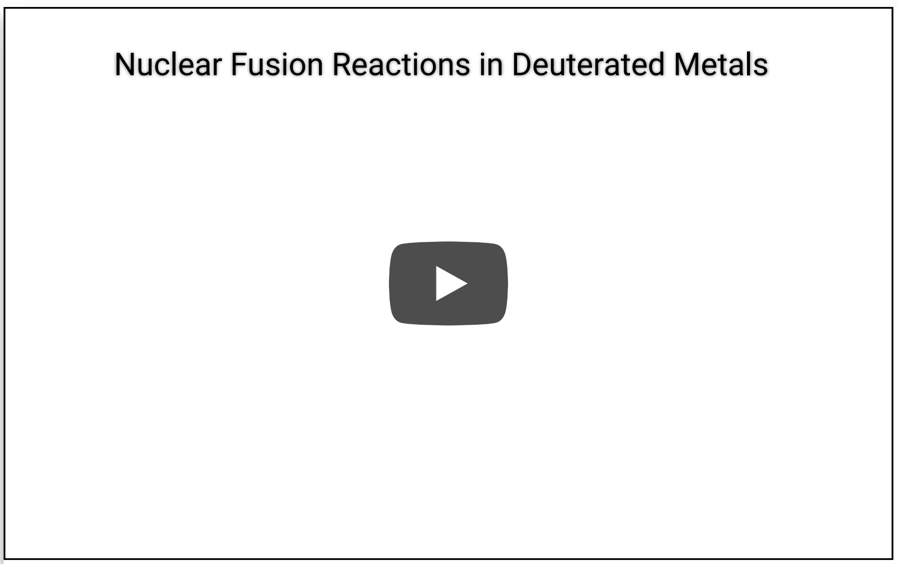


The GRC Team’s LCF Journey



Nuclear Fusion Reactions in Deuterated Metals

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