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Establishing a touchstone experimental platform for investigation of low-energy nuclear reactions in metal hydrides

Over the past several decades, there have been dozens of reports of anomalies from hydrogen isotopes embedded at high densities in metal lattices. These anomalies include neutron and charged particle emission, changes in elemental and isotopic composition, and heat generation, suggesting a novel class of nuclear reactions. Because of the low stimulation energies involved, these have been described as low-energy nuclear reactions (LENR). The innovation agency of the US Department of Energy, ARPA-E, has recognized LENR as "a potentially transformative carbon-free energy source[1];"however, progress in the field has been hindered by two primary challenges: difficulties in achieving consistent experimental reproducibility and the absence of a theoretical framework that connects these observations with established physics.
Here, we report on our attempt to resolve the issue of reproducibility by establishing a well-characterized reference experiment. In this campaign we seek to reproduce the findings of four independent reports of such LENR effects in metal-hydrogen systems subjected to low-energy laser and/or thermal stimulation[2-5]. The targets, which include palladium and titanium thin films, foils, and pressed pellets, are thoroughly characterized by SEM EDS and laser ablation ICP-MS both before and after stimulation, to capture any changes in morphology and elemental or isotopic composition. During hydrogen evolution within the metals, we monitor high-energy particle emission and changes in temperature and pressure which may be signatures of LENR.

To facilitate and promote further investigation of these systems, we have developed an open-source experimental platform, which we present here along with results from our ongoing studies. Additionally, to address the theoretical gap, we have identified quantum mechanisms that may underlie these effects [6], including Dicke-enhanced supertransfer and nuclear deep strong coupling. The implications of these quantum phenomena for LENR are examined further in companion presentations by Matt Lilley and Jonah Messinger.

[1] U.S. Department of Energy. U.S. Department of Energy announces $10 million in funding to projects studying low-energy nuclear reactions. https://arpa-e.energy.gov/ (2023, February 17).
[2] Mastromatteo, U. J. Condens. Matter Nucl. Sci. 19, 173–182 (2016).
[3] Uchikoshi, T. Kyoto University Thesis, (2020).
[4] Nassisi, V. & Longo, Fusion Technol. 37, 247–252 (2000).
[5] Beltyukov, I. L. et al. Fusion Technol. 20, 234–238 (1991).
[6] Metzler et al. New J. Phys. 26 101202 (2024).

Theme

Theme 2. Quantum effects in energy processes and materials

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