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Research Article

Experiment on Detecting Neutrons Produced by Low-Energy Nuclear Reactions Using CR-39

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Abstract

We designed an experimental setup to qualitatively reveal the existence of low-energy nuclear reactions or other possible nuclear processes during laser irradiation, by detecting fast neutrons. Inspired by the experimental scheme first proposed by MIT, laser emitters projecting red light with a wavelength of 445 nm were utilized to target titanium and palladium metal sheets inside chambers filled with helium, hydrogen, deuterium, or argon gas. After 30 days of laser irradiation, a large number of fast neutron tracks were found on both sides of the detectors. Counts were estimated to be one order of magnitude higher than the background, warranting the argument that titanium and palladium sheets, when loaded with certain gases and exposed to prolonged laser irradiation, can produce neutrons. Elements not originally present were detected, consistent with possible transmutation. The new elements due were discovered in most of the samples, and were largely consistent with the neutron production.

Keywords: LENR, Laser, Neutron, CR-39.

1. Introduction

From 2016 to 2022, scientists from all over the world, such as Mastromatteo, Biberian, Barrowes, and Uchikoshi, carried out laser low-energy nuclear reaction experiments and measured transmutation elements and neutrons.

In 2023, Florian Metzler and colleagues at MIT put forward an experimental scheme, which is the first attempt to test the hypothesis of low-energy fission reaction. The experimental scheme of MIT is to irradiate palladium or titanium metal targets with lasers in an atmosphere of hydrogen or deuterium, and detect neutrons and nuclear fragments to prove the existence of nuclear processes.

Inspired by MIT's experiment, we designed and fabricated a simple reaction device, based on MIT's drawings. Accordingly, laser experiments were carried out on four gases and two metals, and the nuclear products, including neutrons were detected primarily with CR-39, a solid-state nuclear track detector. Here is a brief introduction to some of the preliminary results of our experiment.

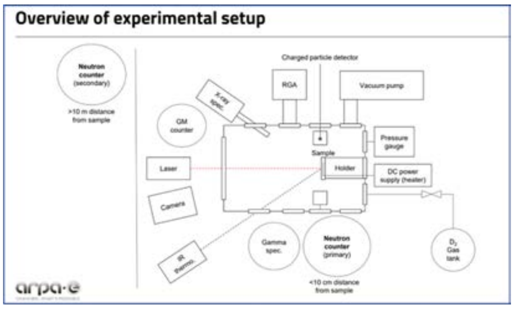

Figure 1. Schematic posted by MIT for the verification of laser-stimulated LENR by detecting neutrons.

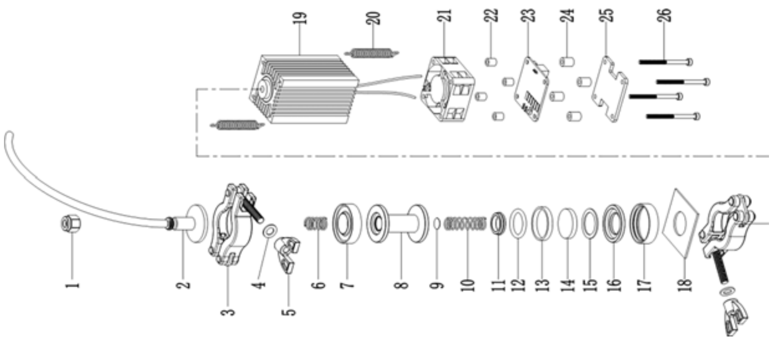

Figure 2. Exploded view of mechanical parts showing the structure of the container. The outer diameter of the container is 14 mm, the diameter of the laser point is 1 mm, the laser output power is 3-5 W with a wavelength of 445 nm, the diameter of the metal sheet is 9 mm, and the thickness for each of metal sheet is 0.1 mm.

2. Methods

Before the experiment started, calibration was conducted with CR-39 detectors covered by film. Only the neutrons passing through the detectors will leave certain tracks. Alpha particles will leave nuclear tracks on the naked CR-39, but they are blocked by the film cover.

The CR-39 detection efficiency was calibrated with a standard americium-beryllium (Am-Be) neutron source at the National Institute of Metrology, China, using a BARYOTRAK detector (Fukuvi Chemical Industry, Co.). The Am-Be neutron source had an activity of 10^7 Bq, and it produced dozens of tracks. The pits were counted using a microscope. The counting results gave a detection efficiency, which was about 4440 neutrons to produce one pit. The CR-39 used in the calibration was also covered with a protective film to block incident alpha particles, so only pits left by neutrons are counted.

After being etched with sodium hydroxide solution, pits left by neutrons on both sides of CR-39 can be seen using a microscope. The field of view of the microscope was estimated. The total pits on a CR-39 sample were estimated by multiplying the number of pits in the area of the microscope image by the total area of the chip. The ambient temperature constantly cooled the CR-39, ensuring clear images and accurate counting. The neutron distribution on the chip was uneven. The neutron count is measured at a spot where the laser illuminated the sample, which probably has the highest density of pits. Thus, the estimated neutron count should be higher than the actual one.

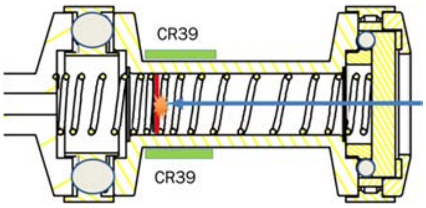

Figure 3. Section view of the container sealed by two pairs of flanges. The blue arrow represents the laser targeting the metal sheet.

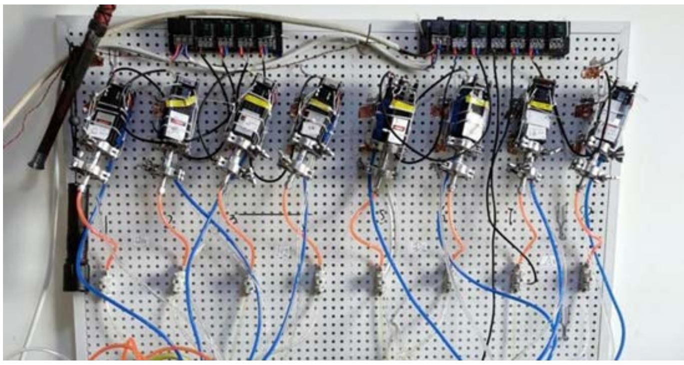

Figure 4. Top view for 8 laser emitters cooled by tap water. The containers next to them are evacuated then filled with specific gases.

The experimental system consisted of eight containers holding the metallic samples. Either a palladium or titanium sheet was placed inside the chamber perpendicular to axial direction, facing the directed laser at a right angle, ready for irradiation. Noble gases including helium and argon gases and isotopes of hydrogen gas, i.e., deuterium and hydrogen, were employed to carry out the experiment. The power of the laser emitter is between 3.5 to 4 watts, thereby producing a strong heating effect inside the containers. Hence two CR-39 samples were attached to the exterior surface of the container, about 13 mm away from the laser focal point upon the sheets. Another CR-39 sample 7 mm away from the focal point was placed inside the chamber for reference.

After the installation was completed, each chamber of the container was evacuated and then filled with a pure gas. When the gas charging is complete, all the gas pressures were kept at around 1 atm. The container was sealed and the laser was turned on to start the experiment. The number of pits on CR-39 left by neutrons was counted after 5 days and again after 30 days of continuous laser irradiation. The titanium and palladium sheets were retrieved after irradiation and sent to the Tan Kah Kee Innovation Laboratory in Xiamen, Fujian Province, for EDS analysis to see if there was change in elements.

3. Results

The titanium sheet was apparently scorched after laser irradiation. The scorch mark can be seen with the naked eye. New elements were detected at the dark spot at the exact location targeted by the laser beam. In contrast, no scorched spots from laser irradiation were found on the palladium sheet after the exposure, thus making it difficult to map the exact location where the laser targeted the palladium surface. Indeed, no new elements were found on the palladium sheet in container 2, while new elements were detected in other containers.

Table 1. New elements found on 11 or 10 spots selected from the scorched location on Ti. The fraction represents the ratio of specimens with a specific new element over the total specimens selected from the surface of the sheet.

New Elements Found on Ti							
Gases	**Label**	**Si**	**Fe**	**Al**	**Ca**	**Ni**	**S**
He	1	4/11	2/11	0	0	0	0
H_2	3	10/10	2/10	1/10	1/10	2/10	1/10
D_2	5	10/10	1/10	0	0	0	0
Ar	7	1/10	0	0	0	0	0

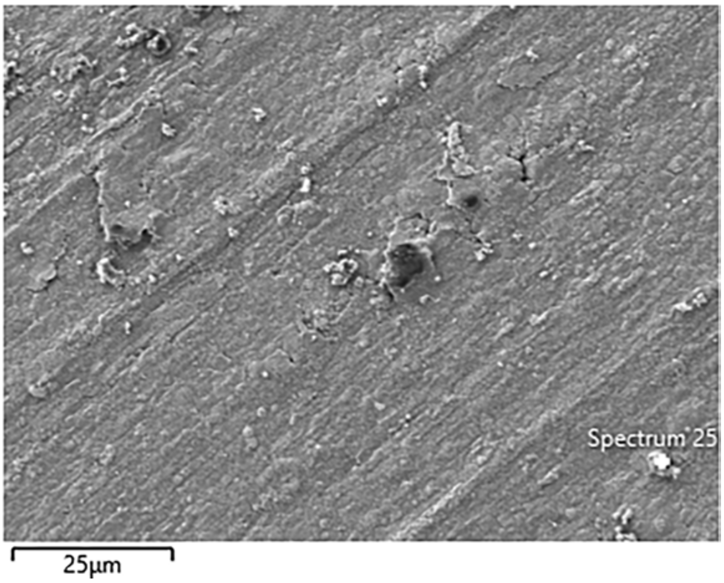

Figure 5. "Spot NO. 25" within the scorched position on the Ti sheet after 30 days of exposure in H_2 where six new elements, i.e., Si, Fe, Al, Ca, Ni, S were detected using EDS.

After five days of laser irradiation, nuclear tracks due to the neutrons were compared with the neutron tracks gathered from National Institute of Metrology, and then were counted and recorded. Neutron tracks were detected on CR-39 for all eight containers. As for the most "active" sample, i.e., the helium loaded Titanium sheet exposed to laser, it was estimated that about 200 neutrons were emitted per second per container on average, which is higher than the background by a factor of three. For each container, calculation was conducted based on average number of pits per cm^2 denoted as $n_i(i = 1,\ 2,\ 3, ..., 9)$. The value of n_i times 4440, as was mentioned earlier, gives the entire number of neutron emitted during the 5 or 30 days. The time duration for the experiment is denoted as t_j(in seconds, $j = 1,\ 2$). The total area of the imagined sphere having the radius represented by the average distance between the CR-39 and the targeted spot, which is 13 mm in this case, is 21.24 cm^2. The number of neutron emitted per container was estimated to be:

$$\frac{n_i \times 4440}{t_j} \times 21.24\,\mathrm{cm}^2$$

Table 2. New elements found on 10 spots selected from the exposed surface on Pd.

New Elements Found on Pd										
Gases	**Label**	**Au**	**Fe**	**Mg**	**Na**	**Ni**	**Pt**	**Ag**	**S**	**Si**
He	2	0	0	0	0	0	0	0	0	0
H_2	4	1/10	0	0	0	0	1/10	0	0	0
D_2	6	0	2/10	2/10	1/10	0	0	0	0	2/10
Ar	8	0	0	1/10	5/10	1/10	0	1/10	1/10	1/10

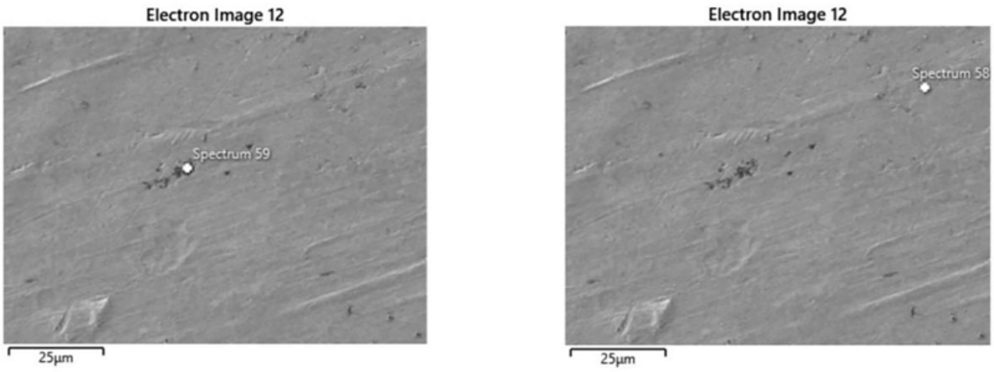

Figure 6. An example of spots selected from Pd exposed to D_2 gas and laser for 30 days where new elements Fe, Mg, Na, Si were found via EDS analysis.

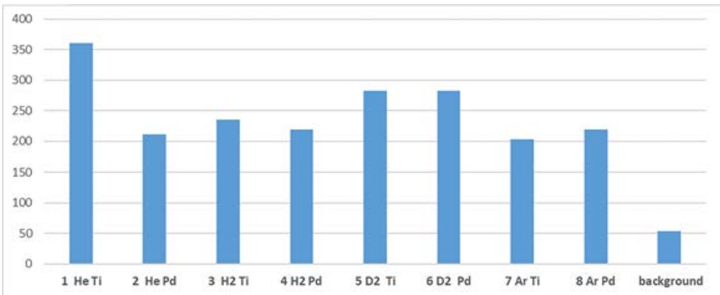

Figure 7. Counts per second (CPS) estimated for the eight chips after 5 days' laser exposure. Whenever there was a difference in the counts from the pair of chips around the same container, the larger number would be used.

The control group employed CR-39 with the same gases but without laser stimulation. The quantity of pits left on the chip inside the chamber was found to be influenced by partial melting caused by the high temperature within the chamber, making it difficult to cunt the number under a microscope.

After 30 days of laser irradiation, nuclear tracks were again counted and recorded. Neutron tracks were detected on CR-39 for all 8 containers. It was estimated that during this period, about 100 neutrons were emitted per second on average, about one order of magnitude higher than the background.

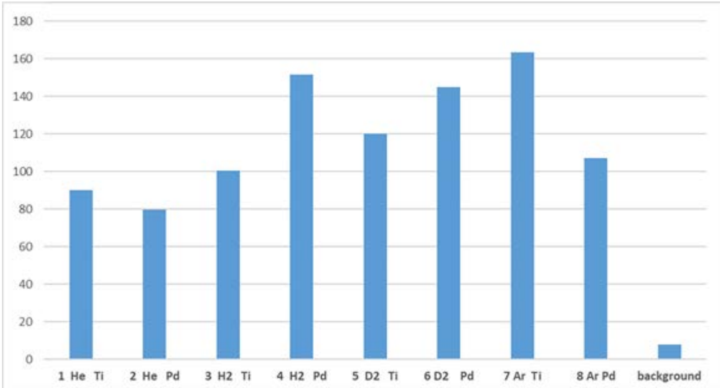

Figure 8. Counts per second (CPS) estimated for the eight chips after 30 days of laser exposure.

In summary, three implications may be deduced from the above experimental results:

1. Neutron tracks were detected using CR-39 after laser irradiation of titanium and palladium in different gases. The average neutron generation was about 100-200 counts per second (cps), and the distribution density of neutron tracks was uneven. Neutron flux turns out to be different for the first 5 days and the remaining 25 days of the experiments. Furthermore, there seems to be a large variation in the number of background neutrons.
2. Possible transmutation elements were detected in most samples of titanium and palladium after laser irradiation in different gases. Among them, Fe, Al, Ca, Ni, Na, Mg, seem to be from fission reactions, rather than fusion reactions. However, the discovery of Ag, Au and Pt indicates fusion reactions also took place. Unlike titanium, palladium after exposure showed no evident scorched spot. Thus the elemental analysis from container No. 2 may still be valid since the specimens might be simply selected from the wrong place.
3. For titanium, loading with hydrogen produces the most abundant new elements, while for palladium, loading with argon produces most abundant new elements. Silicon was occasionally found on the sample without laser irradiation, and its presence in irradiated sample might be owing to a physical dominated process of phase change and diffusion, rather than transmutation. The same hypothesis applies to oxygen and carbon (which were not listed in the table), which are difficult to distinguish from the background at present.

4. Discussion

The accuracy of the experiment is limited by many factors during the gas loading and irradiation. There was a potential slow leakage of the chambers so extra gas was needed to intermittently refill the chamber. Only the cumulative number of neutrons can be counted. There is no way to know the exact time of the neutron bursts.

The reported neutron flux is higher than other papers reporting neutrons captured from LENR. But when the same experiment was repeated with scintillator or He-3 neutron detector, no signals were detected. The low detection efficiency might be the reason for the mismatched results. The energy of the neutrons needs to be studied in depth using real-time detectors or even neutron activation analysis (NAA).

Neutrons have been detected in Ti and Pd in the four types of gases, among which two are inert gases. This counter-intuitive result may assist in gas loading and laser stimulation experiments in future, and broaden the scope of LENR.

This experiment is a preliminary attempt to replicate MIT's experimental scheme. It qualitatively supports the existence of nuclear processes during laser irradiation upon certain metals. However, the evidence is as yet insufficient to analyze the properties of the tracks left in the CR-39.

The distribution of new elements is dominated by fission reaction products, rather than fusion reaction products. Currently, no clear correlation can be drawn between the neutron flux and the abundance of possible transmutation elements. The experiments need to be repeated to understand the rule governing the distribution of elements.

In the next step, we plan to use real time detectors with better sensitivity. Because of the low neutron quantity, it is necessary to design a special moderator and a combined measurement scheme to increase the detection efficiency, and capture more information regarding the tracks left on CR-39. This work is in progress. We also realize that the counting and the spherical approximation for calculating the emitted neutron is only a rough approximation. More repetitions are needed to address the problem of random error that may appear in a single experimental run and invalidate the result.

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References

[1] Probing neutrons and purported fission daughter products from gas-loaded, laser-irradiated metal-hydrogen targets. Principal Investigator: Yet-Ming Chiang, Professor, MIT Presentation by Florian Metzler, Research Scientist, MIT

[2] Laser induced transmutation in palladium thin films in hydrogen atmosphere. Jean-Paul Biberian, Pamela Mosier-Boss, Larry Forsley. Aix-Marseille University, France Global Energy Corporation, U.S.A.

[3] LENR Anomalies in Pd–H2 Systems Submitted to Laser Stimulation Ubaldo Mastromatteo, A.R.G.A.L. Via S. Stefano, 27 – 20010 Bareggio (MI), Italy