Was Transmutation Observed at the Quantum Rabbit Laboratory?

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It has been over twenty years now since Pons and Fleischmann claimed to have observed evidence of nuclear reactions occurring at low energies in a tabletop experiment, reporting an output of excess heat that could not easily be explained as the result of any chemical processes.[1] If such a finding could be confirmed it would hold enormous promise for future technologies, possibly providing a clean and safe solution for the world's energy needs. But soon after the announcement by Pons and Fleischmann, other researchers failed to reproduce their results, and the majority of scientists came to consider "cold fusion" dead.

Nevertheless, there is a small minority of scientists still performing experiments in the field of LENR (low-energy nuclear reactions), a newer term that was introduced later to replace "cold fusion." LENR experimentalists have made various claims of success, but these have not been sufficient to provide evidence so compelling that it would be generally accepted. There are reports of excess heat in newer experiments using better measuring techniques, but this cannot be reproduced with sufficient consistency and the observed heat is only on the order of magnitude of the heat entering the experiment—not enough to heat a cup of tea and not enough to convince skeptics. Evidence of particle tracks in CR-39 plastic sheet detectors that may have been produced as a result of nuclear reactions has been obtained at a U.S. Navy laboratory,[2] but even this evidence has not been strong enough to convince the majority of scientists.

The most direct proof of nuclear reactions would be the appearance of substances that were not originally present, strongly suggesting transmutation of nuclear elements, provided that contamination can be ruled out. Most experiments are focused on the reaction of deuterium or ordinary hydrogen nuclei, which would produce helium or tritium. But at least as far as He^4 is concerned it occurs naturally in our atmosphere, making it hard to rule out contamination. A more promising indicator would be the production of heavier elements involving larger nuclei, as long as large enough concentrations could be obtained. In addition, these transmutation products would surely have isotopic compositions[3] that deviate significantly from the ones found in natural occurrences of the elements. This could be just the evidence that supporters of LENR would need to convince a large majority of scientists. There are some experimentalists who claim to have observed such unusual isotopic compositions. But as Michael Schaffer[4] wrote in a 1999 article for *Scientific American* about the status of low-energy nuclear reactions, "Production of such heavy nuclei is so unexpected from our present understanding of low-energy nuclear reactions, that extraordinary experimental proof will be needed to convince the scientific community." As of today, that has not been achieved.

Enter Quantum Rabbit. Quantum Rabbit is a small laboratory in Nashua, New Hampshire run by Edward Esko, Alex Jack and Woodward Johnson. Remarkably, they started their experiments without any special expertise in nuclear physics. They have performed various experiments where they have seen the anomalous appearance of different substances, which they suggest may be a hint of transmutations, that is changes in the nuclear structure of their test substances. In their most promising experiments, the purported transmutation products showed up in concentration in the order of magnitude of thousands parts per million within the materials used in the experiments, as measured reliably by outside laboratories. In order to rule out the possibility that the detected substances could have been present before the experiment, certified pure samples were used for all the test materials and the test tubes used were carefully examined for contaminants as well. The best effort was made to avoid contamination throughout the experiment. A typical experimental set-up they used is depicted in Figure 1. Various kinds of test materials, like lithium or sulfur, were placed in a vacuum tube between two metal electrodes. The air was then pumped out of the tube and oxygen was pumped back reaching a pressure of a few Torr. Electricity was then applied to the electrodes and the test material was heated until it started evaporating. Both electrodes, as well as the test materials, were then sent to a laboratory where they were tested for traces of various elements that should not have been present at the beginning of the experiment.

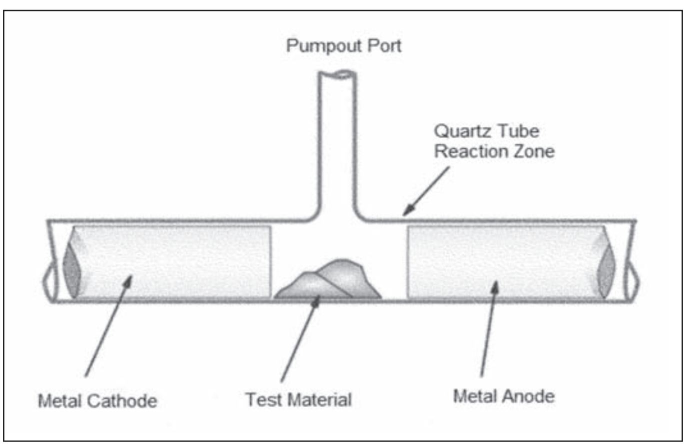

Figure 1. A typical Quantum Rabbit set-up.

Interestingly enough, the elements that were detected afterward could well be explained as fusion products of the elements that entered the experiment. For example, using iron electrodes with lithium as a test material, copper was found after the experiment. A quick look at the periodic table confirms that a copper nucleus would result from simply combining a nucleus of iron and lithium, without additional reactions like beta decay or electron capture that would further change the end products. I have compiled an excerpt of some of their tests results in Table 1. The suggested transmutation product was commonly found both on the test substance residues and on the electrodes; the value listed is the higher one observed.

In another type of experiment, non-metallic graphite or silicon powders (scientific grade 99.999% pure) were placed in a pure (99.999%) graphite crucible. The powders were charged with 36 volts of direct current through a pure (99.999%) graphite rod. The crucible was connected to the negative pole, the rod to the positive pole of a power pack consisting of three 12-Volt solar-charged batteries. The powders received between 100 to 200 strikes from the charged rod. Upon cooling the powders were tested for magnetic properties with a neodymium magnet before packaging and shipping them to an outside lab for EDS and ICP analysis. Very clearly the treated graphite powders showed magnetic properties, which could point to the possibility that magnetic metals like iron, cobalt or nickel were produced by transmutation of the carbon. However, one needs to be aware of the fact that carbon itself was found in 1997 to have an allotrope (a specific form of an element, *e.g.* graphite and diamond are the more common allotropes of carbon), carbon nanofoam, that turned out to exhibit ferromagnetic behavior like iron.[5] Thus evidence of magnetism alone is no proof that it is caused by iron, cobalt or nickel resulting from transmutation. Nonetheless, the chemical analysis of the graphite powder shows 4700 ppm iron, along with other elements, notably silicon at 1.5%.

One might think that the concentrations of putative transmutation products seen in the Quantum Rabbit experiments could be large enough to be considered a giant breakthrough in the field of LENR, but so far these experimental results have garnered very little attention. These results are so contrary to established theory that it is extremely hard to accept them, much harder than most other LENR evidence that is focused on reactions between hydrogen isotopes like deuterium. For deuterium—having only one positive charge each—the mutual electric repulsion between nuclei known as the Coulomb barrier is as small as it can get. Still, even for deuterium it seems extremely difficult to explain theoretically how this repulsion can be overcome to accomplish nuclear reactions in systems with low energy and low density. For most scientists it therefore sounds like suggesting that an ant is capable of pushing a baby stroller, making it hard for LENR to find general acceptance. The idea of nuclear reactions between heavier nuclei as supposedly observed in the Quantum Rabbit experiments goes far beyond that—it is more like suggesting that an ant is pulling a freight train. The electric repulsion becomes so forbiddingly strong that such reactions at low energies would be thoroughly ruled out by the known laws of physics, particularly by the laws of electricity that have been extremely well established and extremely well confirmed. Conventional physics tell us that it requires pressures and temperatures comparable to those of the interior of the sun to overcome the Coulomb barrier even for the very lightest elements in order to achieve fusion. But, for fusing heavier elements as suggested by the Quantum Rabbit experiments, only cataclysmic scenarios like supernova explosions will suffice.

When only singly charged nuclei like ordinary hydrogen or deuterium are involved, one may try to think of some extraordinary mechanism that could explain how the charge of the nucleus may be neutralized by an electron, like the temporary formation of a deflated state,[6] or even by wildly speculating that a proton and an electron can temporarily combine to form a neutron[7]—just to name two examples without giving any credence to any particular theory (see my criticism of Widom and Larsen[8]). The point is, finding such a mechanism for singly charged nuclei like ordinary hydrogen or deuterium is already extremely difficult, and none of the existing explanations are entirely convincing to say the least. But when it comes to nuclei with higher charges it would require some collective effect involving many electrons at once to neutralize the entire charge of the nucleus, which seems all but impossible.

The most obvious conclusion is that transmutation can be ruled out as an explanation for the results reported by Quantum Rabbit, as nuclear reactions at such low energies strongly contradict the established theories of physics. One might ask though if this could be a hint that the established theories are wrong, or at least if there may be some entirely new physical phenomena involved that cannot be explained within the current theories. After all, it often turns out that discrepancies between existing theories and experimental results prove to be gateways to revolutionary changes in our understanding, bringing about radical paradigm shifts. Would the experiments at Quantum Rabbit be able to bring about such a radical change? Most scientists would consider that highly unlikely, probably even most researchers in the field of LENR. Furthermore, LENR as proposed by Quantum Rabbit is most at odds with the extremely well established laws of electromagnetism worked out by Faraday and Maxwell in the nineteenth century, as it is the immensely strong electric repulsion that would prevent the nuclei from coming close enough together to allow for a nuclear reaction. And even if one could devise a theory that can explain how that repulsion can be overcome, it still has to be consistent with all other evidence. The new theory must not predict nuclear reactions to be happening much more easily

Table 1. Some Quantum Rabbit test results.

Fe + Li → Cu	1500 ppm	(anode)	stainless electrodes with lithium test substance
Zn + S → Pd	91 ppm	(sulfur residue)	copper/zinc electrode with sulfur test substance
Zn + O → Sr	14 ppm	(anode)	copper/zinc electrode with sulfur test substance
S + O → Cr	198 ppm	(sulfur residue)	copper/zinc electrode with sulfur test substance
Ag + Li → Sn	3 ppm	(lithium residue)	copper/silver electrode with lithium test substance
Cu + Li → Ge	2190 ppm	(cathode)	copper electrodes with lithium test substance
C + O → Si	138 ppm	(cathode)	graphite electrodes with sulfur test substance

Fe	iron	O	oxygen
Li	lithium	Sr	strontium
Cu	copper	Cr	chromium
Zn	zinc	Ag	silver
S	sulfur	Sn	tin
Pd	palladium	Ge	germanium

and frequently in other scenarios than is actually observed, especially if it would entail catastrophic consequences. For example, it may be difficult to explain why the hydrogen in the sun does not immediately get converted into heavier elements by a giant explosion instead of getting it slowly consumed over billions of years. But beyond that it may be hard to explain why transmutations are not easily observed as a commonplace occurrence in many other experiments.

While the experimental results may look quite intriguing, the researchers at Quantum Rabbit are well aware that there are still possible sources of contamination that have not been properly addressed. They agree that going forward in this line of research their experiments would have to be repeated at a research institute or an established laboratory. One could take the viewpoint that the arguments against LENR of heavier elements are so compelling that transmutation has to be ruled out, and therefore any attempt to look deeper into the matter would be a waste of time and resources. This would be similar to the highly skeptical viewpoint that most scientists have towards LENR research in general. On the other hand, what is special about the experiments at Quantum Rabbit is the fact that they have been achieved with relatively modest means. It might therefore be well worth the effort to try to reproduce at least some of their results, focusing on obtaining stronger evidence in favor or against transmutation with some easily performed experiments.

There are some obvious steps that could be taken next. First and foremost, it would be quite revealing to test the isotopic composition of the putative transmutation products. Isotopes are variations of nuclei that have the same number of protons and thus behave the same chemically, as it is their charge that determines their interaction with the electrons, but they differ in the number of neutrons in their nuclei. Most elements consist of a mix of various isotopes, and when found in nature there is very little deviation in their relative abundance. This is often used as some kind of fingerprinting of materials, as their compositions differ ever so slightly when they come from different origins. When produced by transmutation, however, one would expect radical deviations from the ordinary mix. For example, if we look at the suggested reaction Fe (iron) + Li (lithium) → Cu (copper) in detail we find that copper found in the environment is made up of about 69% Cu^{63} consisting of 29 protons + 34 neutrons = 63 total, and 31% Cu^{65} with 29 protons + 36 neutrons = 65 total. Lithium consists mostly Li^{7} (3 protons + 4 neutrons) with an abundance of about 92.5% and of Li^{6} (3 each) at 7.5%. The only simple fusion reaction yielding Cu^{65} would therefore be $Fe^{58} + Li^{7} \rightarrow Cu^{65}$, since Fe^{59} is not stable and does not occur in nature, ruling out the reaction $Fe^{59} + Li^{6} \rightarrow Cu^{65}$. But natural iron contains only 0.28% Fe^{58}, consisting mostly of Fe^{56} with 92% and some other isotopes lighter than Fe^{58}. One would therefore expect very little Cu^{65} from the transmutation reaction. If the analysis of the copper isotopes found in the experiment showed a fairly large proportion of Cu^{65} anywhere close to the natural 31% it would be a clear indication that the copper detected was not a result of transmutation, but most likely came out of the environment as contamination. If on the other hand the analysis of isotopes showed an apparent lack of Cu^{65} it would bolster the claim of transmutation considerably.

Similar tests of the end products could be performed for many of the other experiments. If the silicon found in the graphite experiment was obtained by transmutation of lighter elements, like carbon + oxygen or even nitrogen + nitrogen from the atmosphere, one would expect it to be almost exclusively Si^{28}, with considerably less than 4% Si^{29} that is found in naturally occurring silicon. Analyzing the nickel found in the same experiment could provide even more valuable clues. Nickel naturally consists of a pronounced mix of isotopes, mostly Ni^{58} with 68%, Ni^{60} with 26%, and Ni^{62} with 3.6%, which may make it easier to observe clear deviations in the isotopic composition.

Future experiments could be devised with the goal of maximizing the evidence obtained by analyzing the isotopic composition of the supposed transmutation products. One of the most promising examples could be to repeat the Quantum Rabbit experiments using manganese + lithium in an attempt to produce nickel. Manganese has only one stable isotope, Mn^{55}, and lithium is 92.5% Li^{7} and 7.5% Li^{6}, thus one would expect mostly Ni^{62} and some Ni^{61} from a simple fusion of manganese and lithium nuclei. But these two isotopes make up only less than 4% of naturally occurring nickel. Ordinary nickel on the other hand consists of 94% of the lighter isotopes Ni^{58} and Ni^{60}. This should make it obvious whether any observed nickel was produced by transmutation or originated from contamination. Even if more complicated reactions could occur turning Ni^{62} and Ni^{61} into lighter isotopes, for example by neutron emission, the isotopic composition of any nickel obtained by transmutation would likely deviate considerably from that of ordinary nickel, thus providing conclusive evidence.

A very important point to note about the isotopic composition is the effect that contamination has on the evidence. Simply testing for concentrations of various elements in treated test samples as has been done so far has the problem that contamination can result in false evidence. With respect to isotopic composition, on the other hand, contamination would diminish the evidence, as any contaminants from the environment would have the naturally occurring mix of isotopes. Thus, if the analysis of the end products were to show a highly anomalous isotopic composition, it would be strong evidence for something unusual going on, warranting further research.

Some other simple and straightforward tests could be performed as well. It would be simple enough to test for particle radiation by inserting a cheap CR-39 plastic polymer, a technique often used in other LENR experiments. If any hints of radiation are found it could be taken as a possible indication that nuclear reactions have indeed occurred. With a little bit of creative thinking one can come up with other tests that could be simple enough to perform. So far the researchers at Quantum Rabbit have been more focused on testing for elements that would be expected from nuclear reactions of the substances involved in the experiment—but what about looking for elements that would not be expected as end products of nuclear reactions? For example, while iron + lithium would be expected to yield copper, what about using either cobalt + lithium or nickel + lithium in the experiment instead, with cobalt and nickel being the elements following iron in the periodic table? Would one still see copper as an end product, maybe in similar concentrations as in the iron experiment? If so it may be an indication that the copper detected after the experiment resulted from some contamination and not from transmutation, which should result in zinc or gallium instead that come after copper in the periodic table.

How likely is it that a small laboratory in New Hampshire with simplistic experimental set-ups was able to achieve nuclear reactions that are thought to be only possible under such extreme conditions as found in supernova explosions? If low-energy nuclear reactions between heavier, more highly charged nuclei are possible, why was that not detected and firmly established long ago by generally accepted experiments? The arguments against transmutation seem compelling and it may seem inevitable to conclude that it has to be ruled out, contamination being a much more likely explanation. The researchers at Quantum Rabbit themselves admit to that possibility. However, as remote as the possibility of LENR of heavier elements may seem, if it was confirmed it would have earth-shaking consequences, both theoretically and practically. Being in conflict with the current theories of physics, it would possibly pave the way for a new revolution that would likely bring about a completely new understanding of physics. It would surely open the door for a huge number of applications that could introduce radically new industries, like producing iron from coal or copper from iron and lithium, to name just two examples. Further exploration could well uncover new inexhaustible sources of energy from nuclear reactions that could be exploited in safe and peaceful ways. Even if this all seems absolutely far-fetched, it may well be worth the extra efforts to perform a few more simple experiments that can either confirm low-energy nuclear reactions of heavier nuclei in these types of experiments, or rule them out. The result may well turn out to be negative as conventional physics would predict, but if so, we will have made sure that we are not passing up a giant opportunity, and we will be able to agree that the established laws of physics have withstood another challenge.

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Matthias Grabiak grew up in Germany and got his Ph.D. in theoretical physics in 1988 at the Johann Wolfgang Goethe Universität in Frankfurt. From 1989 through 1992 he was a post-doctoral researcher at the Nuclear Physics Group of the Lawrence Berkeley Laboratory. He then began working in the software industry and is currently employed with Oracle, while still having a continued interest in physics.

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