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Research Article

Nuclear Metamorphosis in Mercury: Rare Earths Production*

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Abstract

In two previous papers, we described the equipment and the results of an experiment in which nuclear reactions occurred in a mole of mercury, in a condition of Local Lorentz Invariance breakdown. The elemental analyses performed after the (continued in p.2)

Keywords: Deformed space–time, Local Lorentz invariance breakdown, Mercury, Nuclear reactions, Rare earths production

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(continuation of Abstract from page 1) experiment showed the presence of elements which were not part of the set-up before the treatment. However, some of the detected elements were not reported in the results as they needed further analysis. In this final paper, all the elements detected in the above-mentioned experiment are presented along with their concentration measured in the analysed samples. Of particular interest is the presence of some rare earth elements among them.

1. Introduction

In the last few years, Low Energy Nuclear Reactions (LENR) were reported to occur under different experimental conditions. Due to the different methods used to produce these effects, different names were used for them: cold fusion [1,2], piezonuclear reactions [3–6], Condensed Matter Nuclear Science [7] and E-Cat [8]. They have not been widely accepted by the scientific community, mainly because they do not seem to follow the known laws of physics.

Recently, the Deformed Space–Time (DST) theory was suggested [9] as a general theory able to explain the occurrence of all these phenomena.

This theory can be considered as a generalization of General Relativity (GR), which predicts the gravitational interaction as a curvature of space–time. According to the DST theory [10,11], all interactions can deform space–time, thus changing the 4D-metric parameters of the local Minkowskian frame. In this sense, the Riemannian curvature of GR is only a particular case of deformation and not unique [12].

A local deformation of space-time corresponds to a violation of the Local Lorentz Invariance (LLI), which, on the contrary, assumes that space–time is locally isotropic, homogeneous and flat.

Energy [10,11] and energy density [6] in space and in time play a fundamental role in this deformation. Four different energy thresholds were deduced [10,11], each one for each of the four different fundamental interactions, starting from the experimental data collected in experiments specifically dedicated to the study of these interactions: the pure leptonic decay of the meson K_0 short for the weak nuclear interaction; the pion pair production obtained in 1984 by the UA1 collaboration at CERN for the strong interaction; the superluminal propagation of electromagnetic waves in conducting waveguides with variable section for the electro-magnetic interaction; the relative rates of clocks at different heights in the gravitational field of Earth for the gravitational interaction.

The DST reactions possess three peculiar characteristics: the existence of an energy density threshold to be reached and overtaken, which may also result in a delay of the reaction start; the spatial anisotropy; the time asymmetry and asynchrony, which correspond to the emission of aperiodic intense beams having a very short life-span and different chronological structure rather than continuous emissions of particles.

Besides, in the case of DST nuclear reactions, the absence of gamma radiation has also been always experimentally verified [4,9,19,20] and can be considered as a further signature of the DST nuclear reactions. Some or all of these characteristics have been also reported [9] by several authors in LENR.

Following a previous experiment [13–15], where the anisotropic emission of neutrons from a steel bar subjected to ultrasound was attributed to the LLI breakdown, a new experiment was conceived [16]. The target was to induce the breakdown of LLI in a mole of mercury and hence the initiation of DST nuclear reactions.

The striking result of this experiment consisted in finding in the matrix of mercury chemical elements whose presence had already been excluded by the initial blank analyses. The atomic mass of these elements was both heavier and lighter than that of mercury. This fact is unusual as nuclear fusion reactions usually produce heavier nuclei, but not heavier then iron, while nuclear fission reactions produce lighter nuclei, but not lighter then iron. In this case, on the contrary, reactions could occur in both directions, irrespective of the position with respect to iron.

After 180 s of treatment of the mole of mercury, some solid material appeared floating on top of the still liquid mercury. A thorough and careful elemental analysis of each part of the experimental equipment (initial mercury, container, ultrasound conveying implements, final mercury and of the course the solid material) was carried out by different analytical techniques.

An element of this solid material was considered as a reliable reaction product if it was detected by at least two different techniques and if it was neither present in the initial mercury pool nor in the container nor in the used tools.

This data rejection rate is very severe since an element which does not comply with the requirements above is excluded also when it is present as a different isotope. Besides, it is also excluded even if the element is detected by different investigators in different laboratories if their instruments use the same technique.

A subsequent paper [17] announced the results obtained in a laboratory enabled to release official certification. They confirmed previously reported results.

Due to the stringent requirements adopted to accept an element as a reliable reaction product, several elements and isotopes were discarded and hence not reported in the previous two papers [16,17]. In contrast, for the sake of completeness and in order to gain the global picture of the outcomes collected in this experiment, all the elements and isotopes detected as reaction products, with the only limitation of not being part of the blank, are listed in this paper.

We point out that we are not presenting a new set of experiments confirming the results of those previously reported, but we present new information about the results obtained by analysing the material produced after the previous experiment.

2. Experimental

One mole of mercury (0.2 kg) from SPHERAE SRL (Gorizia, Italy) declared 99.99% pure, was treated making use of the Startec reaction system dedicated to DST reactions and built up according to the patents reported in [16].

Due to the restrictions connected to the patent, the technological details of the reaction system cannot be described here. However, the physics and the scientific details that are the basis of the instrument are reported in Section 1, and are widely discussed in the papers related to DST-theory.

We are aware of this limitation, which is usually not widely discussed in the scientific literature. Nowadays, the distance between Science and Technology is becoming shorter and shorter since the time interval between the scientific finding and the technological application is shorter than in the past. However, different laws rule the two worlds that, in this sense, are widely separated. We think that respecting the rules of the technological world is a duty of the scientist, so we will just summarize the related patents, without giving details.

The experiment lasted 3 min and was repeated 10 times in one year, between 2012 and 2013. Each time, a solid material formed and was extracted from the remaining liquid phase.

The initial temperature was 20±2°C while the final temperature was 260±2°C. They were measured by infrared thermometer Fluke 68 IR.[a]

In the year 2016, the spatial concentration of energy was slightly modified in three trials although the same source, the same power and the same total energy released to the sample were used. In these cases, no formation of solid material was observed and the temperature increase was smaller (20±2°C–80±2°C).

As forecast in the DST-theory, the energy concentration rather than the total energy is of fundamental importance. In these cases, the necessary conditions to create the LLI breakdown were not attained and the DST-reactions did not occur. For this reason, the corresponding three samples were not further considered.

In the first instance, the composition of the formed solid phase was analysed together with some residual part of Mercury. In the second instance, before analysing this material, it was heated at 400°C in Nitrogen flux inside a Pyrex container (the so-called stripping procedure), with the aim of eliminating mercury.

The latter procedure, however, also eliminated other elements. In particular, Bromine was detected by three different techniques in the first step while it was not detected in the second one.

The composition of solid material was investigated by using different techniques in different Italian institutions:

- Inductively coupled plasma optical emission spectroscopy (ICP-OES).

Instrument: Perkin Elmer optical emission spectrometer OPTIMA 8300/at Università Politecnica delle Marche – Ancona (UNIVPM).

- Inductively coupled plasma mass spectroscopy (ICP-MS).

Instrument: Thermo Fisher X series II/at National Council for Researches, Rome (CNR).

- ICP-MS.

Instrument: Perkin Elmer OPTIMA 2100 DV/at CNR.

- ICP-MS.

Instrument: Agilent 7005C octopole reaction system/at CNR.

- Environmental scanning electron microscopy with energy dispersive spectroscopy (ESEM+EDS).

Instrument: FEI Quanta 200/at University of Urbino.

- ESEM+EDS.

Instrument: LEO 1450 VP LAIKA Cambridge at Università di Roma 1 – Rome.

- Scanning electron microscopy with energy dispersive spectroscopy (SEM+EDS).

Instrument: FEI x120 with EDAX ECON 4 EDS/at UNIVPM.

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[a] By the way, in a previous paper [16] it was erroneously quoted as model 69.

- Scanning electron microscopy (SEM).

Instrument: SEM Cambridge Stereoscan 250 MK3/at ENEA-Rome.

- X-ray fluorescence (XRF).

Instrument: Spectro x-Lab2000/at CNR.

- Instrumental neutron activation analysis (INAA).

Instrument: Gamma detector with high purity Ge by ORTEC (HPGe ORTEC) at nuclear reactor TRIGA Mark II-upgrade/at ENEA- Casaccia.

These techniques were also used to determine the elemental composition of the blank: mercury from the initial pool; pieces of the vessel containing the mercury in the reaction device; parts of the tools in contact with mercury inside the device; parts of the same tools not in contact with mercury.

Further analyses [17] were performed at the CAIM laboratory (Follonica – Grosseto, Italy), accredited by Accredia as lab.#0437. In fact, International agreements ensure the validity and credibility of accreditation as an effective instrument of qualification of operators and of conformity assessment on the European and world market. They used the standard method UNI EN 13656:2004, which defines the mineralization of a solid sample, necessary before feeding it into an analytical device, by using a microwave digestion system (in this case: mineralization system Ethos 1 - Advanced Microwave Digestion System), and the standard method UNI EN ISO 17294-2:2005, which describes the instrumental measurement of metals by using ICP-MS (in this case: model 7700 – Agilent Technologies).

3. Results

As explained in the introduction, only the elements that were detected by two different techniques, and that were not among the elements of the blank, were considered reliable reaction products. These are reported in [16]. Further results satisfying less stringent conditions were also reported in [17], as explained in Section 2.

Both data are gathered in the second column of Table 1. On the other hand, the results relevant to the present paper can be found in the third column of the same table. This column contains a list of elements or isotopes that had been detected but were not reported in the previous works, due to the severe conditions imposed on the determination of the suspected reaction products.

When allowed by the detecting technique (INAA or ICP-MS), the isotopes of the elements are reported in the table. In this case, the position of the isotope by natural abundance on the Earth is also indicated. The concentration of the reported isotope can be evaluated from that measured of the corresponding element by considering the natural abundance.

The fifth column of Table 1 shows the techniques by which the element or isotope was detected.

Calcium (^{43}Ca) was also detected among the products. However, it is not reported in Table1, as it is usually considered ubiquitously present.

4. Discussion

Ninety are the natural elements on the Earth: among them, 19 were excluded from the reaction products because they were present in the devices and original mercury pool; 11 are gaseous at room temperature and pressure and thus could not be detected in our experimental conditions. Among the remaining 60 elements, Table 1 shows that 28

Table 1. Reaction products of the DST-reactions in mercury ordered by atomic number Z. The elemental concentrations in column 4 is related to the analysed sample, not the whole mole of mercury. In bracket, isotope position by natural abundance on the Earth: 1st, 2nd, 3rd, ... isotope; mono represents naturally monoisotopic element on the Earth.

Z	Element/isotope in [16,17]	Other detected element/isotope	Elemental concentration	Detecting techniques
3	^{7}Li (1st)		0.40±0,05 ppb	ICP-OES ICP-MS
4		^{9}Be (mono)	0.004 ± 0,001 ppb	ICP-MS
22	^{47}Ti (3rd)		7800 ± 800 ppm	ICP-OES ICP-MS ESEM
23	^{51}V (1st)		0.10 ± 0,03 ppb	ICP-MS INAA
27	^{59}Co (mono)		34 ± 2 ppm	ICP-OES, INAA XRF
28	^{58}Ni (1st)		186 ± 20 ppm	ICP-OES INAA XRF ICP-MS
31	^{69}Ga (1st) ^{71}Ga (2nd)		84 ± 10 ppm	ICP-MS XRF INAA
32		Ge	2780 ± 300 ppm	XRF
34	^{78}Se (2nd) ^{82}Se (4th)		240 ± 25 ppm	ICP-MS XRF
35	^{79}Br (1st)		77 000 ± 5000 ppm	ESEM INAA XRF
37		Rb	335 ± 35 ppm	XRF
39		^{89}Y (mono)	56 ± 8 ppm	ICP-MS INAA
42		^{95}Mo (3rd) ^{98}Mo (1st)	1113 ± 3 ppm	ICP-MS INAA
48		^{111}Cd (3rd)	6 ± 2 ppm	ICP-MS XRF
49		^{113}In (2nd)	10820 ± 120 ppm	INAA
50	^{118}Sn (2nd) ^{124}Sn (6th)		6 ± 0.6 ppm	ICP-MS INAA XRF
51		^{121}Sb (1st) ^{123}Sb (2nd)	0.30 ± 0.13 ppm	ICP-MS INAA
58	^{138}Ce (3rd) ^{140}Ce (1st)		34.5 ± 4,0 ppm	INAA ICP-MS
63		^{151}Eu (2nd)	31 ± 7 ppb	INAA
64		^{152}Gd (7th) ^{158}Gd (1st)	417 ± 17 ppm	INAA
70		^{174}Yb (4th)	57 ± 24 ppm	INAA
71		^{176} Lu (2nd)	141 ± 37 ppm	INAA
72	^{177}Hf (3rd)		450 ± 50 ppm	INAA XRF
75		^{185}Re (3rd)	30 ± 3 ppm	INAA
78		^{190}Pt (6th) ^{195}Pt (1st) ^{196}Pt (3rd)	1332 ± 9 ppm	INAA ICP-MS INAA
79	^{197}Au (mono)		0.07 ± 0,01 ppb	ICP-MS INAA
90	^{232}Th (mono)		35 ± 5 ppm	INAA XRF
92	^{238}U (1st)		114 ± 20 ppm	ICP-MS XRF

are considered reaction products. Calcium could have also been counted in, as it was only detected in the produced material.

Beside the ability of DST-reactions to produce both lighter and heavier nuclei from those of the starting material, as already remarked in previous works [16,18], it is also interesting to note that six of the 17 rare earths[b] were also detected in the formed material: yttrium, cerium, europium, gadolinium, ytterbium and lutetium. This fact could be the starting point for a new way to produce them, thus also eliminating the troubles related to their supply.

Among the 31 elements that were not found, the absence of caesium is particularly important, as it is a harmful product of other nuclear reactions.

A quantitative prediction of the reaction products in a single experiment is not yet possible. In fact, the elements of Table 1 were found inside the solid material obtained from one run. In this sense, the reported uncertainty concerns only the investigated amount of produced material and is not obtained over different runs.

Moreover, the primary reactions, supposed to occur in conditions of LLI breakdown, could produce elements that, in turn, produced other elements in secondary reactions. These last could either occur in condition of LLI breakdown or in accordance with the LLI.

We can thus argue that, although the control of the conditions producing DST-reactions is attained in this experiment, a fine determination of the reaction paths would require long systematic investigations, which now are out of the aims of our study.

In any case, the DST nuclear reactions, which have also been observed to occur without concomitant dangerous gamma emissions [4,9,19,20], appear to be very promising both from a fundamental and an applicative point of view.

Finally, we remark that the occurrence of nuclear reactions in mercury subjected to some kind of stress was also reported by other authors (see [21,22] and references therein). Similarly to our case, those investigations can be classified as "LENR in mercury" due to the types of reactions and the characteristics of the experimental apparatus.

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