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Nuclear metamorphosis in mercury

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The conditions of local Lorentz invariance (LLI) breakdown, obtained during neutron emission from a sonicated cylindrical bar of AISI 304 steel, were reproduced in a system made of a mole of mercury. After 3 min, a part of the liquid transformed into solid state material, in which isotopes were found with both higher and lower atomic mass with

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respect to the starting material. Changes in the atomic weight without production of gamma radiation and radionuclides are made possible by deformed space–time reactions.

Keywords: Local Lorentz invariance breakdown; local Lorentz invariance violation; deformed space-time reactions; piezo-nuclear reactions, ultrasound; nuclear reactions; matter transformations; transmutations; solidification; second law of thermodynamics.

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1. Introduction

A new type of nuclear reactions, called piezo-nuclear reactions, was suggested to occur in ultrasound-induced cavitation phenomena[1] when the variations of energy density correspond to a breakdown of local Lorentz invariance (hereafter LLI or "Lorentz invariance").[2]

Piezo-nuclear reactions are a particular case among the reactions occurring in deformed space–time conditions (DST-reactions).

The theoretical basic principles of these phenomena were developed in the pioneering work of Petrucci *et al.*[3] while the subsequent experimental data were the starting point for the precursor work of Mignani *et al.*,[4] which predicts that the course of the whole Aston–Bohr–Wheeler "nuclear curve" (see e.g., Refs. 4 and 5) is open in both directions.

The main steps of these investigations, looking for the LLI breakdown, concern the energy thresholds of the fundamental interactions for space–time deformations,[2] the corresponding energy density inside the "Ridolfi cavities" of metallic materials,[6,7] in particular considering the leptonic and hadronic interactions and finally the energy rate or "time density" of energy, as discussed in Ref. 2, where the transformations of time intervals in hadronic interactions are considered. Anisotropy of hadronic interactions is a consequence of the anisotropy of the hadronic metric and its variations with energy.[8]

In order to check this anisotropy, a dedicated experiment was designed and realized in Rome (Italy) in 2012[9]: the angular distribution of neutrons produced by DST-reactions in a steel bar subjected to ultrasound irradiation was registered. The experiment is based on the results previously obtained in Milan (Italy) and Cagliari (Italy) in 2010.[10–12] The crucial point in these experiments is the comparison of angular distributions with those obtained in 1999 in electromagnetic systems testing LLI violation.[13]

A further step of the path is reported in this paper. In fact, the results from the previous experiments are exploited to reach the conditions of LLI breakdown and thus to induce nuclear transformations in mercury.

The Rome experiment[9] was designed to study the spatial distribution of the neutron energy produced by means of DST-reactions. It is based on previous experiments realized in Milan and Turin, which concerned the piezo-nuclear neutron emissions from steel, ferritic iron and basalt submitted to ultrasounds.[10,12]

In the Rome experiment, a cylindrical bar of AISI 304 steel — having 9 cm height, 2 cm diameter and 180 g mass — was irradiated for 3 min by ultrasounds

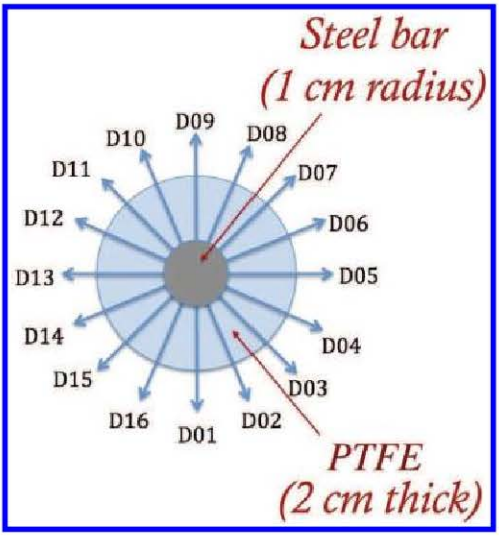

Fig. 1. Geometry of the experiment in Rome (see Ref. 9): a steel bar of 2 cm diameter, surrounded by 2 cm thick PTFE calorimeter, is irradiated by 20 kHz ultrasounds. Sixteen neutron detectors made of PADC polycarbonate are set all around the PTFE casing. The 16 (horizontal) directions normal to the detector surfaces (from D01 to D16) are reported in figure.

with frequency 20 kHz. The sample was held vertical and its lateral surface was surrounded by 2 cm thick PTFE of 188 g mass. Sixteen neutron detectors made of PADC polycarbonate and each one immersed in boric acid were set all around this PTFE calorimeter, in order to register the intensity distribution in a horizontal plane, normal to the axis of the sample (Fig. 1). The images obtained from these detectors were calibrated by comparison with those obtained after exposition to a neutron beam of known intensity from the channel of a nuclear reactor making use of 94% enriched Uranium.[14]

During 3 min of ultrasound irradiation, the steel bar temperature raised from 20°C to 92°C, while the PTFE melted (its melting temperature is 327°C) and was also locally carbonized. From these facts, the energy supplied to the steel bar was evaluated about 6 kJ, while the energy deposited in the PTFE calorimeter was more than 60 kJ.

After this evaluation, about 6 kJ was assumed as the energy supplied to the bar by the ultrasound generator, while the much larger energy transferred at higher temperature to the calorimeter was assumed as deposited from the emitted neutrons.

The distribution of energy transferred by the neutrons along a horizontal plane was obtained from the images of the 16 PADC detectors and is reported in Fig. 2: the resulting distribution is very anisotropic and asymmetric. The directions of maximum intensity, corresponding to 25 + 22 μSv (detector D10 and D02) and minimum intensity, corresponding to 0 + 0 μSv (detectors D06 and D14) are mutually perpendicular.

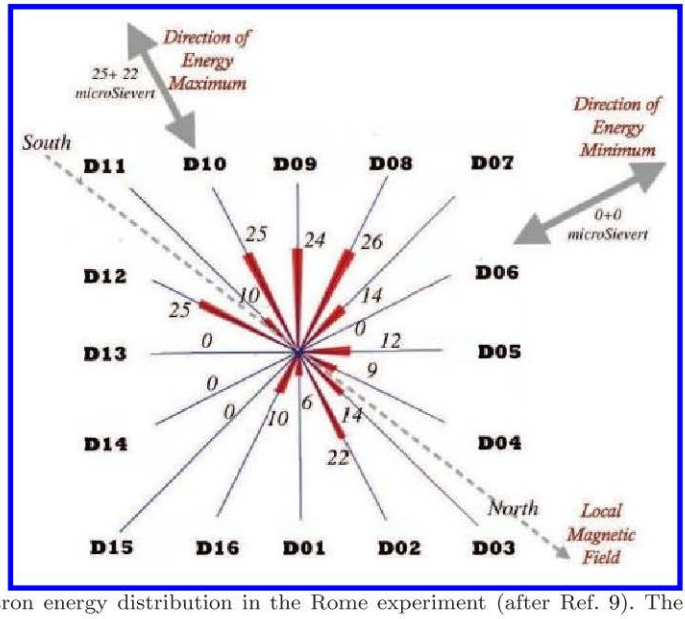

Fig. 2. Neutron energy distribution in the Rome experiment (after Ref. 9). The length of the central lines is proportional to the reported dose (μSv) registered in the corresponding detector. The evaluated incertitude varies between 0.2 μSv (at 0 μSv) and 3 μSv (at 26 μSv). A possible calibration error only induces a systematic factor. The direction of the local terrestrial magnetic field is also reported.

A reference frame was considered having a main axis in the direction of the local terrestrial magnetic field, in order to compare these results with the anisotropic behavior observed in the electromagnetic experiments of 1999,[13] which are the bases of the deformed special relativity and the geometrical representation of the interactions with energy dependent metric.[2,8]

In those previous experiments, the Lorentz invariance breakdown was observed when the investigated direction formed a clockwise angle of about $5\pi/4$ rad with the North direction of the terrestrial magnetic field. In the Rome experiment, this angle lies between the D09 and D10 detectors, which is the region of maximum intensity (Fig. 2).

This coincidence of the LLI breakdown direction with the direction of maximum emitted energy was considered a strong support to the suggestion that the neutron emission and the corresponding nuclear reactions occur in condition of Lorentz invariance breakdown, thus also including its asymmetry.

All these taken into account and also considering that DST-reactions have been reported both in ferritic liquids and in ferrite bars after sonication,[10,15] we designed an experimental apparatus aiming to obtain transformations of the matter by supplying energy in condition of Lorentz invariance breakdown, as deduced after Rome experiment (Fig. 2). The corresponding instrumental device was build up by Startec Ultrasuoni Ltd. making use of the Startec patents reported in Ref. 16. The results of the experiment are reported in the next paragraph.

2. Transformations of Mercury

In previous experiments,[6,7,9,10,15] DST-reactions were suggested to produce nuclear transformations in metal-containing materials, in particular if iron was present.

Starting from this point, we aimed at producing DST-reactions in mercury. In fact:

- The nuclear energy density of mercury is about 8 MeV/nucleon, which is not far from the corresponding value in iron: 8.9 MeV/nucleon. Thus, some minutes or at most about 10 min were evaluated to be the time necessary for reaching the DST-reactions threshold (to be compared with the 3 min of the experiment in Rome reported in the previous paragraph).
- The mass density of mercury and its thermodynamic properties allow a power between 10 and 10^3 Watt/mole to be supplied. This range was characteristic of the previous piezo-nuclear experiments and was considered an "energy rate" (or better an "Energy density in Time") suitable for violating the Lorentz invariance.[2]
- Mercury, like other metals, is considered suitable to produce a remarkable high number of different elements in a detectable amount after DST-reactions.

In particular, we aimed at reproducing the conditions of Lorentz asymmetry, already assumed to occur in the previous experiments, also in the case of mercury. The corresponding modifications of the devices and systems are contained in patents of Startec[16] and were used in the present experiment.

Other different conditions were also used three times, in order to avoid not necessary restrictions to the whole apparatus: as it will be reported below, different results were obtained in these three cases and we attributed the difference to not attained conditions of Lorentz asymmetry.

2.1. *Instruments and methods*

We used the Startec reaction system considered optimal to produce DST-reactions and the related Lorentz asymmetry.[16] During one year (between 2012 and 2013) the optimized system was used 10 times, while nonoptimized systems were used 3 times.

Each experiment lasted 3 minutes and made use of one mole of mercury (0.2 kg weight). This amount of material has been taken from a pool that was kept in the laboratory: thus any difference between treated and nontreated material is not attributable to changes of the laboratory environment, which was the same for both.

In all the 10 optimized cases, the starting room temperature of the sample was $20 \pm 2°C$, as measured by infrared thermometry (Fluke 69 IR Thermometer); after 3 min, a part of the mercury transformed into solid material and the final temperature was $260 \pm 2°C$. A picture of the starting material is reported in Fig. 3 while Fig. 4 shows the solid material obtained at the end of the transformation.

Fig. 3. Experiment in Milan: picture of mercury before treatment.

Fig. 4. Experiment in Milan: picture of the solid material obtained after 180 s of treatment.

No visible amount of solid material was obtained in the three cases when the optimal conditions were not used.[16] The final products obtained in such conditions are no longer considered in the paper.

In order to investigate the effects of the treatment in optimal conditions, also the reaction vessel and the parts of the device close to mercury were analyzed, beside the starting and the resulting materials.

In particular, both parts of the device in contact and not in contact with mercury were analyzed separately. The formers became dark, while the latters maintained their original color.

The studied samples are:

(a) Solid material found in the vessel after treatment in optimal conditions.
(b) Nontreated mercury (from the same pool of treated mercury).

(c) Parts of the device[16] in contact with mercury (dark color).
(d) Parts of device[16] not in contact with mercury.
(e) Portions of reaction vessel.

The following analytical and investigation techniques have been used:

(A) Inductively coupled plasma optical emission spectroscopy (ICP-OES) at UNIVPM. Instrument: Perkin Elmer optical emission spectrometer OPTIMA 8300.
(B) Inductively coupled plasma mass spectroscopy (ICP-MS) at CNR-Rome. Instrument: Thermo Fisher X series II.
(C) ICP-MS at CNR-Rome. Instrument: Perkin Elmer OPTIMA 2100 DV.
(D) ICP-MS at CNR-Rome. Instrument: Agilent 7005C octopole reaction system.
(E) Environmental scanning electron microscopy (ESEM) with energy dispersive spectroscopy (EDS) at UNIURB. Instrument: FEI Quanta 200.
(F) ESEM with EDS at UNIROMA1. Instrument: LEO 1450 VP LAIKA Cambridge.
(G) Scanning electron microscopy (SEM) with EDS at UNIVPM. Instrument: FEI x120 with EDAX ECON 4 EDS.
(H) SEM at ENEA-Rome. Instrument: SEM Cambridge Stereoscan 250 MK3.
(I) X-ray fluorescence (XRF) at CNR-Rome. Instrument: Spectro x-Lab2000.
(J) Instrumental neutron activation analysis (INAA) at ENEA-Casaccia. Instrument: Gamma detector with high purity Ge by ORTEC (HPGe ORTEC) at nuclear reactror TRIGA Mark II-upgrade.

2.2. *Results*

By means of these techniques, labeled from A to J, 27 different elements were found in the solid material obtained after the treatment of mercury. This solid material corresponds to the letter "a" in the list of samples reported in Sec. 2.1.

In order to evaluate a lower limit for the number of elements produced during the process, all those that are also present in the pool of mercury (letter "b" in the list of samples) and in the experimental apparatus (letters "c", "d" and "e" in the list of samples) were excluded from the list of produced elements. This cut is very drastic, as an element is excluded on the basis of the atomic number Z, even if the isotope detected after transformation is different. More detailed analyses of the different isotopes are left to forthcoming papers.

The elements found in the original mercury (samples of the type "b") are reported in Table 1. Those found in the experimental apparatus (samples of the type "c", "d" and "e") are reported in Table 2.

After eliminating all the elements reported in Tables 1 and 2 (these tables were assumed also containing possible elements of laboratory environment, as all the investigated parts were in contact with the common environment of the laboratory), we considered as unquestionable products of the transformation only those elements

Table 1. Elements not considered as product of the transformation because they have been found in the original mercury pool (sample "b").

Elements found in the original mercury (Letter "b" in the list of samples)	
Element/Isotope The isotope number is reported if identified by ICP-MS or INAA techniques ("B", "C", "D" and "J" in the list of techniques)	Atomic number Z
As 75	33
Ba 130	56
Sm 144	62
Tb 159	65
W 182	74
Hg 196	80
Hg 198	80
Hg 202	80
Pb 206	82
Pb 208	82
Bi 209	83

Table 2. Elements not considered as product of the transformation because they are present in the experimental apparatus.

Elements found in the transformation system (Letter "c", "d" and "e" in the list of samples)	
Element/Isotope The isotope number is reported if identified by ICP-MS or INAA techniques ("B", "C", "D" and "J" in the list of techniques)	Atomic number Z
B	5
Na	11
Mg 24	12
Al 27	13
Si	14
Cr 52	24
Mn 55	25
Fe	26
Cu 65	29
Zn 66	30
Ag 107	47

detected by more than one of the used techniques. They are listed in Table 3 together with the corresponding maximum concentration detected and the techniques used to detect them.

Beside the products reported in Table 3, which were detected by more than one technique, U-238 was also detected by ICP-OES (technique "A").

The other 16 elements identified by only one technique will be presented and discussed in forthcoming papers.

Table 3. Elements identified by more than one technique as product of the transformation. The detection and analysis techniques are also reported together with the highest measured concentration.

Element/Isotope	Atomic number Z	Detection and analysis techniques	Highest concentration measured
Li 7	3	ICP-OES/ICP-MS	0.040 ± 0.005 ppb*
Ti 47	22	ICP-OES/ESEM/ICP-MS	7800 ± 800 ppm
Ni 58	28	ICP-OES/XRF/INAA	186 ± 20 ppm
Ga 69	31	XRF/ICP-MS	84 ± 10 ppm
Se 82	34	XRF/ICP-MS	240 ± 25 ppm
Br 79	35	XRF/ESEM/INAA	77000 ± 5000 ppm
Sn 124	50	XRF/INAA	6.0 ± 0.6 ppm
Hf 177	72	XRF/INAA	450 ± 50 ppm
Au 197	79	ICP-MS/INAA	0.07 ± 0.01 ppb*
Th 232	90	XRF/INAA	35 ± 5 ppm

*These low values refer to the high dilution during the analysis and are also influenced by the low homogeneity of the sample.

3. Discussion

A macroscopic violation of the second law of thermodynamics seems to occur in the above-described transformations of mercury. In fact, a liquid system receiving energy from an external device and increasing its temperature to 240°C, partially transformed into a solid state system, made of different elements, at a temperature more than 300°C higher than the solidification temperature of the starting liquid material. In other words, the degrees of freedom of the system decreased in the transition from liquid to solid, while its temperature increased.

The second law of thermodynamics is not violated, on the other hand, if one takes into account the microscopic nonthermodynamical nature of the occurring reactions,[17] which are of nuclear, not chemical, type. A nuclear source of free energy makes the systems an open system, while thermodynamics describes the properties of the entire ensemble not of a specific part.

The Lorentz invariance breakdown, underlying this macroscopic transformation from liquid into solid at microscopic level, is a further reason for the apparent violation of the second law. In fact, in previous works reporting the LLI breakdown in electromagnetic systems, the Clausius postulate for electric charge distribution was violated and thus the Clausius enunciation of the second law of thermodynamics.[13] (Also discussed in "Energy and Geometry",[2] p. 107).

This paper aims to put in evidence that nonconventional nuclear reactions do occur if conditions of Lorentz invariance breakdown are attained. This is a qualitative but fundamental sentence. In particular, the experimental errors reported above refer to the samples we analyzed. They do not mean to represent the ranges of variations expected for any future case. In fact, different experiments can produce different amount of products, as we observed by analyzing the reaction products after different runs.

Here, a systematic investigation, performed making use of different techniques in different laboratories and concerning a representative case, is reported. The reproducibility we want to remark is that nuclear reactions are obtained in the right conditions, while no dramatic changes are observed in other conditions.

Future works can consider if elements are present in different isotopic states before and after treatment or if different amount of the same isotope are present. These aspects, although of great interest, are of secondary importance with respect to the core subject of this paper and are suggested for future investigations.

4. Conclusion

After a comparison between the above-described Rome experiment[9] and previous results obtained by using Helmholtz coils,[13] we conclude that the same angular asymmetry is characteristic of both electromagnetic and nuclear phenomena in condition of Lorentz invariance breakdown.

After the Milan experiment, main subject of this paper, we conclude that the atomic weight of the matter can change if energy is provided in conditions of Lorentz invariance breakdown and following its asymmetry.

We remark that no gamma radiation above the laboratory background was detected in all of the studied transformations, in agreement with previous results of DST-reactions.[6,10,15] Also, the reaction products resulted free from radioactive emissions and their gamma spectrometry was compatible with the laboratory background.

Considering all the above facts, we conclude that DST-nuclear reactions are not "nuclear transmutations", which correspond to transformations with radiation, but rather transformations of a new type, able to increase the atomic mass by "nucleo-synthesis" or decrease it, by "nucleo-lysis", in a very general way. They are "generalized nuclear reactions", as predicted[4] in the framework of DST theory.[2] In fact, Fig. 5 shows that such "metamorphosis" of the matter are obtained in mercury, in agreement with the forecast generalized nuclear reactions[4]: in particular, starting from mercury, both lower atomic mass isotopes and higher mass isotopes are obtained.

As a matter of fact, the transformations produced stable isotopes, some of which having atomic number higher than iron and mercury while other lower than mercury and iron.

The production of nuclei lighter than iron starting from heavier elements is a relevant fact, mainly in the wake of previous results[7] concerning iron after ultrasound radiation. In fact, also in that case, the curve of Fig. 5 was run in the opposite sense with respect to the up-to-now expected way.

We think that the results obtained in the above experiments and in the previous theoretical and experimental papers are of huge importance both from the scientific and technological point of view. In particular, from the technological point of view, patents are already obtained or are pending.[16] This fact prevents

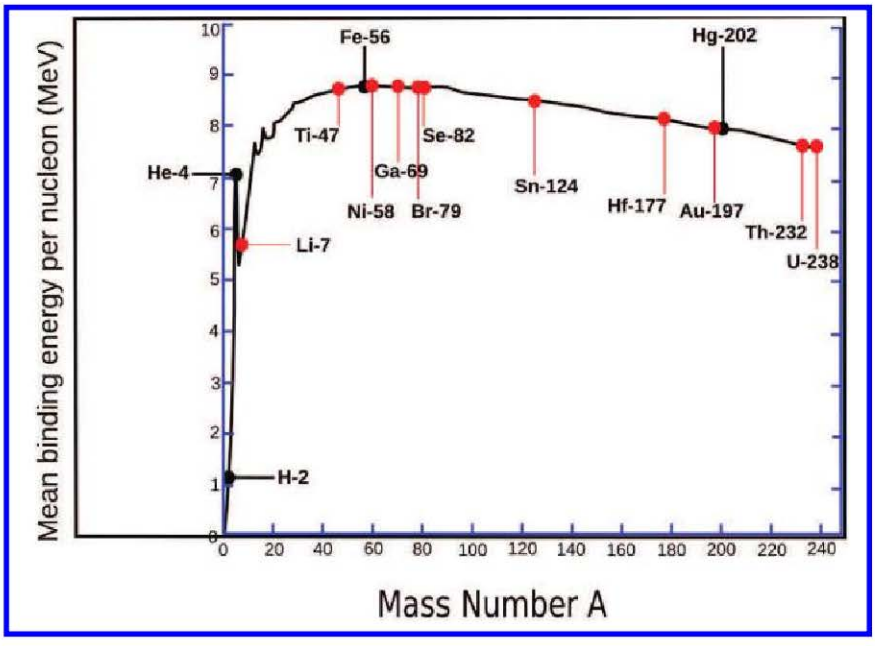

Fig. 5. (Color online) Distribution of the produced isotopes, reported in Table 3, along the curve reporting the average binding energy per nucleon as a function of the mass number A. The lowest nonzero value (H-2), the highest value (Fe-56), the characteristic knee (He-4) and the main isotope of the starting material (Hg-202) are also reported as reference points.

us from describing patented details of the used instrumentation, machinery and devices.

On the other hand, the reproducibility of the results is a fundamental requirement for any scientific subject. We think that in this critical situation, a distinction must be made between the possibility of verifying the results and repeating the same experiment. Concerning the latter point, we repeated 10 times the experiment in the right conditions, obtaining the same results in 100% of cases, while the nonoptimal conditions were used three times, leading neither to solid material nor to temperature increase in 100% of cases. Concerning the former point, on the other hand, the theoretical bases are openly reported and discussed in the publications reported in bibliography: independent verifications based on different device, instrumentation and/or experimental set-up are expected as well.

Claiming scientific priority without violating intellectual property related to the patents (see Ref. 16) is the aim of this paper. Since the laws of nature cannot be patented (Patent Convention Treaty (PCT), Paris 1976 and updates), we believe that the extensive and well-documented bibliography provided in this work allows one to know the laws of nature (the "know-why") that are foundation of these new reactions, so that anyone can develop his own technology (the "know-how") and verify the phenomena.

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