Comparison Between Piezonuclear Reactions and CMNS Phenomenology

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Abstract. The purpose of this paper is to place side by side the experimental results of Piezonuclear reactions, which have been recently unveiled, and those collected during the last twenty years of experiments on low energy nuclear reactions (LENR). We will briefly report the results of our campaign of experiments on piezonuclear reactions where ultrasounds and cavitation were applied to solutions of stable elements. These outcomes will be shown to be compatible with the results and evidences obtained from low energy nuclear reaction experiments. Some theoretical concepts and ideas, on which our experiments are grounded, will be sketched and it will be shown that, in order to trigger our measured effects, it exists an energy threshold, that has to be overcome, and a maximum interval of time for this energy to be released to the nuclear system. Eventually, a research hypothesis will be put forward about the chance to raise the level of analogy from the mere comparison of results up to the phenomenological level. Here, among the various evidences collected in LENR experiments, we will search for hints about the overcome of the energy threshold and about the mechanism that releases the loaded energy in a suitable interval of time.

First of all we would like to warn the reader that due to the limited length allowed for the manuscript we will only mention the results and the main experimental features both for piezonuclear reactions and CMNS experiments and leave the comprehensive descriptions to the references. The subject will be dealt with on a qualitative level since the goal of this paper is only to show a new possible perspective and promote discussion on it.

1. Evidences of Piezonuclear reactions

All of the experiments that we have carried out, involved the application of ultrasounds with a frequency of 20 kHz and suitable power (between 100 and 130 Watts) to liquids either bidistilled deionised water [1, 2, 3] or solutions of bidistilled-deionised water and some standard stable chemical elememts [4, 5]. In [1, 2] we report two evidences: an increase of the proportion of a few high mass number stable isotopes (including uranium) and an increase of the proportion of a few nuclear species within the particular atomic mass range 238<M<264 (including transuranic elements). In the third experiment [3], aimed at detecting elements in the so called rare-earth mass range, ICP mass gave evidence of a significant peak corresponding to a nuclide with atomic mass (137.93±0.01) amu and half-life 12±1 sec, identified as Eu_{63}^{138} . The candidate identified, Eu_{63}^{138}, does not exist in nature; it is an artificial (discovered in 1995-97 [6]) that can be produced at the present time in nuclear reactors and by synchrotrons. The ionising radiation measurements, by LR115 detectors, that were carried out during the application of ultrasounds in all of these experiments, did not provide any evidence of ionising radiation above the background level. Further experiments were designed in order to try and detect possible neutron emission [4,5]. We subjected to cavitation, bidistilled deionised water, solutions of Lithium, Aluminium, and Iron. Being equal all the experimental conditions, but the element, we obtained reproducible evidences of neutrons bursts only with Iron. A further unusual circumstance was the lack of any gamma radiation (above the background level) that usually comes along with the emission of neutrons. Neutrons were measured by three techniques: bubble detectors, Boron screened CR39 and Boron Trifluoride. A further experiment was performed in order to verify the effects of these new mechanisms induced by ultrasounds and cavitation on radioactive nuclei [7,23,24]. The evidences indicated that the initial quantity of Thorium became half in a interval of time 10000 times faster than Thorium half life. However it turned out that this process was not a mere acceleration of the usual Thorium decay by emission of alpha particles, since the number of tracks on the CR39 detectors that monitored the radioactive process was not compatible with this possibility [23,24].

2. Evidences of Low Energy Nuclear reactions

We will try and group the apparently anomalous results obtained by different teams and techniques in LENR in order to point out the possible analogies among these outcomes and those collected in the experiments of piezonuclear reactions. We will summarise the results by referring to the book "The Science of Low Energy Nuclear Reactions" by Edmund Storms [8]. Independently from the method used to induce LENR there were clear signs of transmutations and most of the times the resulting products were Fe, Zi, Cu, Ni, Cr and other nuclides with comparable mass and binding energy per nucleon. Besides, the nuclides belonging to the substrates, used in all of the experiments, had considerable atomic mass ranging from 48 up to 197 amu (Ti, Ni, Pd, W, Au). The environment, in which the substrate was immersed, contained different substances and chemical compounds which contained much lighter nuclides like H, D, Li, Na, K, C, N, O, Cl, and sometimes other heavier ones compatible with the atomic mass of the nuclides of the substrate. Both in piezonuclear reactions experiments and in LENR experiments there are transmutations that involve medium weight or heavy mass number nuclides and produce other intermediate and heavy mass number nuclei[1] (neither fusion nor fission can be invoked [8]). In LENR neutron emission was very low and infrequent while in piezonuclear reactions it was not infrequent but nevertheless it was low and apparently not compatible with known nuclear reactions because of the lack of gamma rays (above the background level). Gamma rays are expected either to follow emissions of neutrons or, at least, to come from the interaction of neutrons and matter (mostly Hydrogen in this case). However, further and more discriminating measurements will certainly be necessary. As to other kinds of radiation emitted during LENR, many different types were detected, which, however have not helped in identifying clear common features among the different experiments and techniques. Among all of them it is worth noting that some teams detected a strange radiation showing unknown features and behaviour [8, 9] which, from our point of view, could be put beside the strange lack of gamma rays which, at least from hydrogen neutron capture, should be emitted. As it will become clear from the next section, it was not our goal to perform extra power or heat measurements during piezonuclear reaction experiments, and hence no comparison can be made on this ground.

3. Local Lorentz Invariance Breakdown

The theoretical background, on which our experiments have been designed and carried out, is based on the concept of breakdown of Local Lorentz Invariance (LLI) [10, 11, 12]. Our phenomenological theory concentrates on the structure of local (microscopical) space-time (flat and rigid according to LLI) when LLI is broken. The coefficients of the local Minkowski metric tensor are hypothesised to be function of the energy of the process. This means that space-time is locally deformed and plays an active part in the dynamics of the physical process whose features and flow deeply depart from their usual appearance. The theory predicts that the space-time of strong interactions begins to be deformed when the energy of the process overcomes a threshold equal to 367.5 GeV [10, 11]. Besides it clearly states that there is no isochrony between the time of the experimenter and that of the hadronic process. To put it in a more practical way, this means that in order to deform space-time around a nucleus (or nuclei) and hence trigger "anomalous" processes, in the fashion of those presented above from piezonuclear reactions, one has to use a microscopical mechanism that loads an amount of energy higher than the energy threshold and then it is capable to release it in an suitable interval of time or in other words it is capable of a

[1] In piezonuclear reactions the heavy nuclides which can be placed side by side to the LENR substrate are those contained in the alloy of the sonotrode.

suitable power (energy divided by time). This theoretical background shows that our experiments were not in wake of the LENR ones, but their target was to obtain some evidences that would corroborate the two predictions mentioned above about the threshold energy and the release mechanism[2].

4. LLI and anomalous nuclear processes

It has been shown that the results of LENR experiments and those of piezonuclear reactions are compatible. Thus, despite the apparent diversity of the experimental set-ups and conditions, it is possible to hypothesise that similar outcomes are brought about by similar microscopical mechanisms that trigger alike anomalous nuclear processes. Now, let us evidence the phenomenological aspects that, within piezonuclear experimental set-ups, fulfil the two conditions mentioned above. Once that these aspects are clear we will try and analyse some LENR set-ups and evidences in order to make out similar features. The collapse of a generic bubble under the huge pressure of ultrasounds, that induces shock-waves on its surface, is regarded as the microscopical mechanism to fulfil the two requirements. As mentioned before, we obtained neutrons only with the solutions of Iron and their emission took place after 40 – 50 minutes the ultrasounds had been turned on, which can be interpreted as the time to reach and overcome the energy threshold. However, the overcoming the energy threshold needs to be referred to the context and the environment where the process takes place and in particular to the types of nuclides involved. The collapse of the bubble concentrates energy in a smaller and smaller region of space (which is actually space-time whose volume is still an open question of the theory), making the energy density higher and higher. In this region of space-time nuclear species are forced. The overcoming of the threshold is achieved by the complementary contributions of the external energy (ultrasounds) and internal energy, i.e. that of the nuclides taking part in the collapse. In this sense, the first preliminary clue is that the higher the atomic mass the less external energy and the shorter time interval it takes to deform locally the space-time. Thus, a first preliminary phenomenological sketch of piezonuclear reactions can be depicted as follows: pressure combined with a mechanism that allows an abrupt release of energy within a suitable interval of time bring about piezonuclear effects. The pressure is produced by ultrasounds, the mechanism is the collapse of the bubble[3]. Their synergy along with nuclides with high atomic mass form the Nuclear Active Environment (NAE) in our experiments. Now let us try and see if it is possible to spot within LENR experimental set-ups, where ultrasounds are not used, the counterparts of pressure and bubble collapse. Due to the preliminary character of these ideas we will focus our attention on one of the many different techniques and in particular on the evidences collected by an electrochemical cell with Pd/D co-deposition which, first of all, is the LENR technique more similar to that used by Fleischmann and Pons and more over it seems the farthest from the piezonuclear reactions set-up. In particular, we refer to the experimental set-up and procedure used by Mosier-Boss et al. which is described in [15]. In their experiments the metals used for the cathode were Ni, Ag, Pt, Au and the solution contained $PdCl_2$ and $LiCl$ or KCl in heavy water. In control experiments $PdCl_2$ was substituted for $CuCl_2$. We will not go through the description of the experimental process, but we will only say that the procedure comprises different phases when the Pd/D co-deposition is formed and when current is periodically increased and an intense electric or magnetic fields is applied. All the details can be found in [15, 16, 17, 18] and the references cited in them. Our target is to look through these details and make out those features that may fulfil the two requirements mentioned above: energy threshold (pressure or energy density) and releasing time (releasing mechanism). Bubble collapse is a far from equilibrium process where energy is locally concentrated around the surface of the bubble and suddenly released with great intensity. Thus, we will have to search in the electrolytic technique for leads pointing toward these three characteristics (far from equilibrium, local loaded energy, local abrupt release of it). From the description in [16] the researchers state that "the experimental protocol covers three time periods" and that the third period of time is used "to put the system in a far from equilibrium condition" which is obtained by applying an intense static electric or magnetic field and by letting the electrolysis proceed by keeping increasing the current from time to time. It is fairly reasonable to consider that a co-deposition of Pd/D is in itself an unstable structure in which atomic bonding between Palladium atoms are deformed, stretched, and weakened by

[2] This explains why we have never used deuterated substance, never look for Helium or Tritium and never attempted to measure the presence of extra heat.

[3] Critical parameters are the dimension of the bubble and the number of ions of the specific nuclide present on the its surface.

the presence of Deuterium. To confirm this, one can put forward the fact that LENR experiments have begun to be carried out in the last few years not by loading Deuterium in bulky Palladium, but rather by co-depositions Pd/D or by nanostructured Pd. These methods produce greater quantities of anomalous evidences than those with solid Pd [8, 15, 19]. That the loading of mechanical energy in Pd is brought about by Deuterium, is confirmed by experiments in which the solution contained $CuCl_2$ instead $PdCl_2$. Copper does not absorb Deuterium, no lattice deformation is brought about, no mechanical energy gets loaded and hence no reactions take place [15]. The statements by Storms [8] in his book seem to move in the same direction. He reports that "...the basic material used as cathode is not active initially even when it is made of Palladium - activation is required. Nevertheless, the base material does affect the morphology and subsequent activity of the deposited layer...". All of these conjectures can be considered a sound and promising lead[4] from the experimental conditions about the possible fulfilment of the first requirement of LLI breakdown hypothesis: existence of an energy threshold. We concentrate now on the second requirement: the mechanism to release this loaded energy. In the experimental accounts [16, 20] the researchers mention a shape change in some areas of the cathode at the end of the electrolysis. Indeed, the structure at the cathode is a complicated and microscopically feeble equilibrium of three layers: the substrate (Ni, Ag, Pt, Au), the co-deposition Pd/D and the solution. We reckon that the application of an electric or magnetic field and the increasing current during electrolysis may generate microscopical conditions compatible with those found in piezonuclear reaction experiments where cavitation took place. As a bubble is a local frail inhomogeneity within a liquid which can be squeezed and deflated[5] by squeezing it using ultrasounds, the locally frail structure of Pd/D co-deposition presents local inhomogeneities or hollows (e.g. gradients of the density of Pd and/or D atoms) whose sudden and violent collapse can be induced by bringing the systems to a far from equilibrium condition (electric or magnetic field, periodical increase of current, continuous flow of Deuterium through the co-deposited layer). As Iron atoms (not light elements) are entrapped in the interface gas/liquid of bubbles and are launched against each other during the collapse and forced in a smaller and smaller volume of space-time until the energy threshold is reached and overcome in a precise interval of time, Palladium atoms might endure similar processes as hollows in Pd/D co-deposition are made collapse. In [8] cracks are indicated as "...the only environments obviously common to all successful experiments...". Always in [8] it is said that Palladium expands as it is loaded with Deuterium and cracks of different dimensions form during this process. Besides cracks are said to be present in Pd/D co-depositions or Palladium black. Some questions are raised as to how cracks are involved in the cold fusion process, or as to how cracks operate to allow Coulomb barrier penetration, or as to how dimensions of cracks influences the formation of a NAE. Eventually, cracks are said to be good candidates to be a NAE. From our point of view and from these statements, cracks can be considered in this experimental system the counterparts of bubbles in cavitation [21,22]. However we reckon that it is not correct look at the NAEs that form in our experiments and in all of the LENR/CMNS experiments from the point of view of the well known nuclear processes and all the concepts involved in them like Coulomb barrier and other quantum mechanical concepts. We believe that this statement is more than corroborated by loads of compatible anomalous evidences collected in these 20 years by different institutions and researchers, different techniques spread all over the world. Before concluding, we would like to point out one more thing. We said that, high atomic mass nuclides contribute to facilitate the overcoming of the energy threshold when they are forced in a smaller and smaller region of space-time. This qualitative picture may induce to think that starting from Palladium, one should obtain heavier nuclei like in a sort of new type nuclear fusion. However in [16] it is reported of transmutations whose products were Aluminium, Magnesium, Chlorine, Silicon which are all lighter nuclides than Palladium. Since these transmutations are thought to be brought about by space-time deformation, it is possible that a heavy nuclide be ripped apart into lighter nuclides by tidal forces i.e., in more picturesque way, as an astronaut would be as he were falling into a black-hole.

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[4] A lead in the sense that deeper investigation, experimental, theoretical and phenomenological will have to be carried on from this point.

[5] We remind that in our phenomenological model the generic bubble deflates while being squeezed by a shock-wave. In other words it is not treated as mean to compress the gas contained in it in order to reach hot fusion conditions.

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