Strong Correlation Between LENR and Nano-Mechanics Instabilities/THz Phonons in Condensed Matter: Applications in Geophysics, Geochemistry, Energetics, Biology

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Abstract: Terahertz phonons are produced in condensed matter by mechanical instabilities at the nano-scale (fracture, turbulence, buckling). They present a frequency that is close to the resonance frequency of the atomic lattices and an energy that is close to that of thermal neutrons. A series of fracture experiments on natural rocks as well as continuous seismic monitoring have recently demonstrated that the terahertz phonons are able to induce fission reactions on medium-weight elements with neutron and/or alpha particle emissions. The same phenomenon appears to have occurred in several different situations and to explain puzzles related to the history of our planet, like ocean formation or primordial carbon pollution, as well as scientific mysteries like so-called "cold nuclear fusion" or the correct radio-carbon dating of organic materials. Very important applications to earthquake precursors, climate change, clean energy production and cell biology can be considered.

1. Fracture and Acoustic Emission: From Hertz to Terahertz Pressure Wave Frequencies

When you cut a stretched rubber band, it remains subject to rapid fluctuations for a few moments. The same phenomenon occurs in any solid body when it breaks in a brittle way, even if only partially. In the case of the formation or propagation of microcracks, such dynamic phenomenon appears under the form of longitudinal waves of expansion/contraction (tension/compression), together with transverse or shear waves. These are generally called pressure waves (or phonons) and travel at a speed which is characteristic of the medium, and, for most of the solids and fluids, presents an order of magnitude of 10^3 meter/second. On the other hand, the wavelength of pressure waves emitted by forming or propagating cracks appears to be of the same order of magnitude of crack size or crack advancement length. The wavelength can not therefore exceed the maximum size of the body in which the crack is contained and may vary from the nanometer scale (10^{-9} meters), for defects in crystal lattices such as vacancies and dislocations, up to the kilometer, in the case of Earth's crust faults. Applying the well-known relationship frequency = speed/wavelength, one obtains the two extreme cases corresponding to the frequency of phonons: 10^{12} oscillations/second (terahertz), in the case of the formation of nanocracks, as well as one oscillation/second (Hertz) in the case of large-scale tectonic dynamics. A correlation is herein considered between the wavelength scale (which coincides with the crack length scale) and the frequency scale by assuming a constant pressure wave speed (Figure 1).

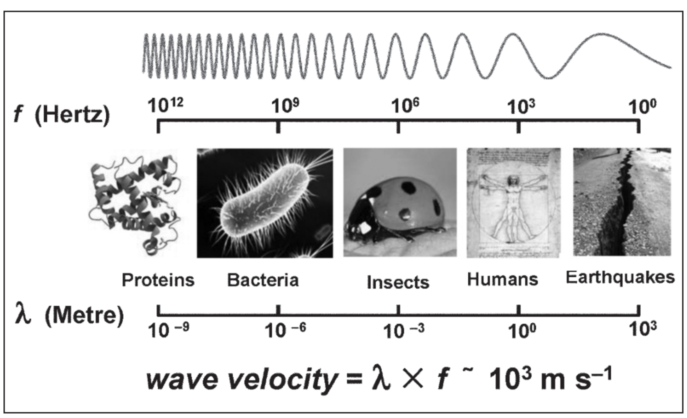

Figure 1. Correlation between wavelength (forming crack length) scale and frequency scale by assuming a constant pressure wave velocity.

As fracture at the nanoscale emits phonons at the frequency scale of terahertz, so fracture at the microscale (10^{-6} meters) emits phonons at the frequency scale of gigahertz (10^9 Hertz), at the scale of millimeter emits phonons at the scale of megahertz (10^6 Hertz), at the scale of meter emits phonons at the scale of kilohertz (10^3 Hertz), and eventually faults at the kilometer scale emit phonons at the scale of the simple hertz, which is the typical and most likely frequency of seismic oscillations.

When the active cracks are still below the meter scale, pressure waves can generate acoustic emission (AE) in the frequency range of ultrasounds (from kilo- to megahertz).

With frequencies between mega- and gigahertz, and therefore cracks between the micron and the millimeter scale, pressure waves can generate electromagnetic emission (EME) of the same frequency.

When pressure waves show frequencies between giga- and terahertz, and then with cracks below the micron scale, we are witnessing a phenomenon partially unexpected: phonons resonate with the crystal lattices and, through a complex cascade of events (acceleration of electrons, bremsstrahlung radiation, photo-fission, etc.), may produce condensed matter fission reactions.[1,2]

Note that the Debye frequency, *i.e.*, the fundamental frequency of free vibration of crystal lattices, is around the terahertz, and this is not a coincidence but is simply due to the fact that the inter-atomic distance is just around the nanometer, as indeed the minimum size of the lattice defects.

As a matter of fact, thermal neutrons are characterized by a frequency of 6.05 THz (according to the well-known law that links energy and frequency through Planck's constant), which is very close to the uranium atomic lattice resonance frequency of 6.24 THz. Therefore, as well as thermal neutrons can trigger fission reactions, so pressure waves with very high frequency (THz) can induce phono-fission phenomena.

Debye resonant frequencies with an order of magnitude of THz are also typical for other medium-weight elements, such as Fe (7.77 THz) and Ca (4.79 THz). That played a fundamental role in the chemical evolution of our planet.

Ultrasonic pressure waves are produced by the most common mechanical instabilities, such as fracture in solids and turbulence in fluids. Both are hierarchical, multi-fractal and dissipative phenomena, where cracks and vortexes, respectively, are present at different scales.

A series of fracture experiments on natural rocks has demonstrated that the terahertz vibrations are able to induce phono-fission reactions on medium-weight elements with neutron and/or alpha particle emissions.[1,3-11] The same phenomenon appears to have occurred in several different situations and to explain puzzles related to the history of our planet, like primordial carbon pollution or ocean formation, as well as scientific mysteries, like so-called "cold nuclear fusion" or the correct radio-carbon dating of organic materials. Very important applications to earthquake precursors, carbon pollution, clean energy production and protein folding can also be proposed.

2. Fracto-emissions as Seismic Precursors

In tectonics, cracking is a multi-scale phenomenon, and the phonon frequencies cover a broad spectrum, from THz for fracture at the nanoscale up to the simple Hz at the kilometer scale. Three different forms of energy emission might be used as earthquake precursors for environmental protection against seismicity. At the tectonic scale, AE prevails, as well as EME at the mesoscale and neutron emission (NE) at the nano-scale. Terahertz phonons are in fact produced at the last extremely small scale.

In this framework, fracto-emissions (AE, EME and NE) can represent a promising tool in seismology, not only for their monitoring capabilities during the earthquake, but also for their forecasting potentialities before the event. In July 2013, an *in-situ* experimental campaign started at a gypsum mine located in Northern Italy (Figure 2a), revealing the strong seismic forerunning potentialities of the fracto-emissions by means of a dedicated monitoring platform (Figure 2b) and a

Figure 2a. The San Pietro–Prato Nuovo gypsum mine located at Murisengo (Alessandria, Italy).

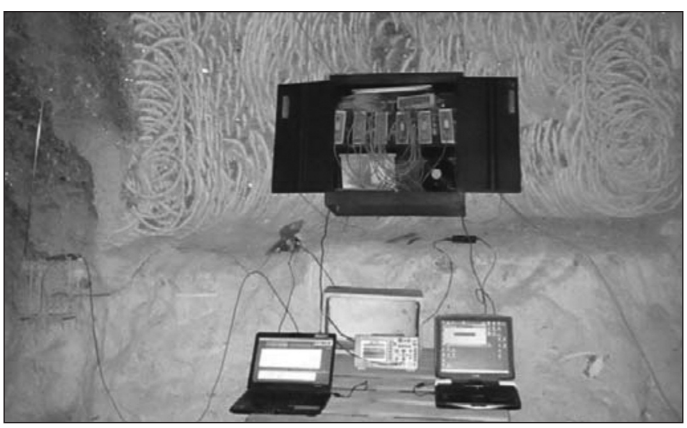

Figure 2b. The monitoring station equipped with the AE piezoelectric sensors, the telescopic antenna and oscilloscope for EME evaluation and the NE proportional counter.

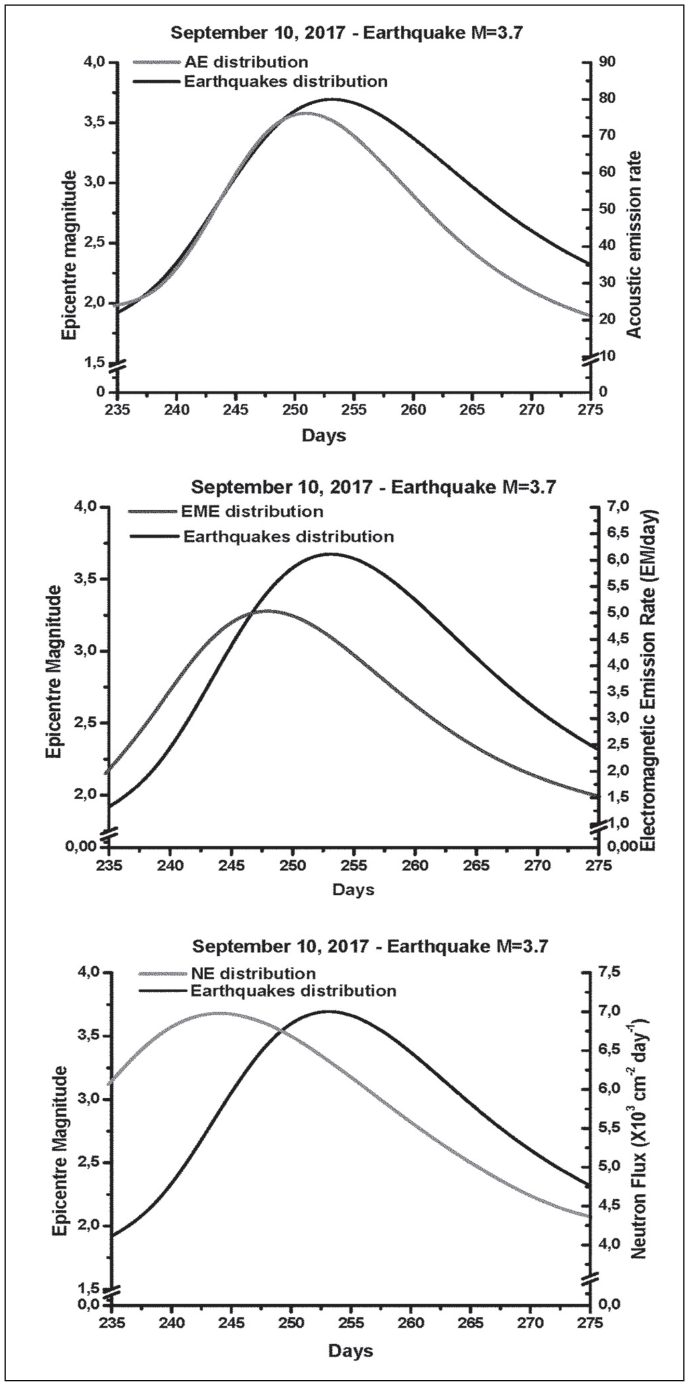

Figure 3. Anticipated and differently shifted Gaussian distributions of AE/EME/NE emissions for the earthquake of September 10, 2017.

multi-modal statistical analysis.

In particular, the three fracto-emissions tend to anticipate the next seismic event with an evident and chronologically ordered shifting: high frequencies with neutron emission firstly, then lower frequencies with electromagnetic and eventually acoustic emissions. The experimental observations reveal a strong correlation between the three fracto-emission peaks and the major seismic swarms occurring in the closest areas. It was noted how AE regularly anticipates the earthquake by about one day, EME by three to four days, and NE by about one week (Figure 3).[12-14]

Therefore, the Laboratory of Fracture Mechanics at the Politecnico di Torino is developing a standard measurement and monitoring procedure performed by a territorial network of several seismic stations.

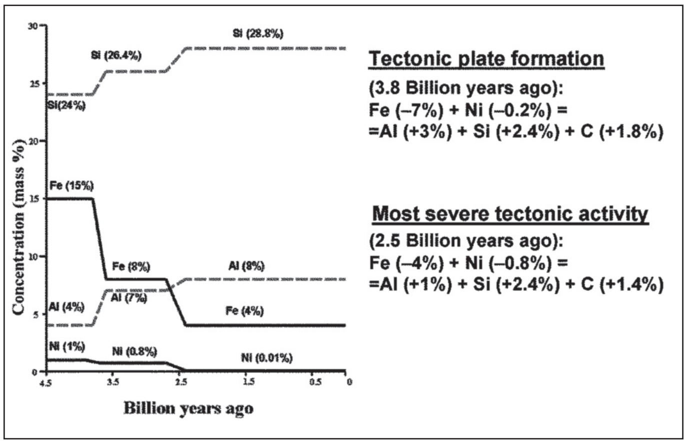

Figure 4. Evolution of the percentages of Fe, Ni, Al, Si and C during the life of our planet (Earth's Crust and Atmosphere).

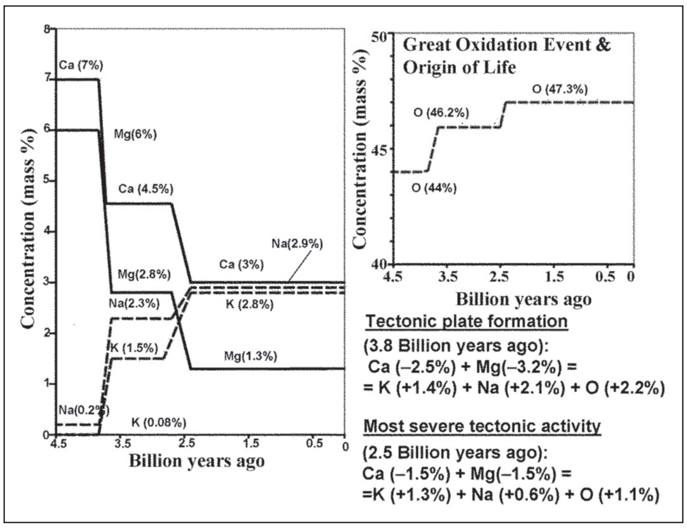

Figure 5. Evolution of the percentages of Ca, Mg, Na, K and O during the life of our planet (Earth's crust).

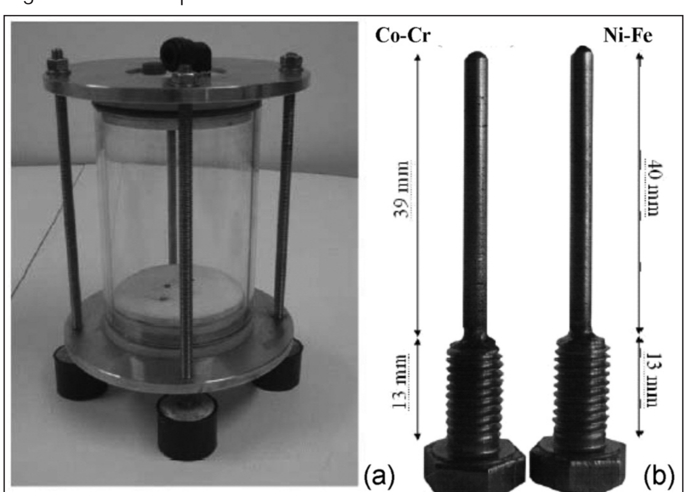

Figure 6. a) The electrolytic cell. b) Co-Cr and Ni-Fe electrodes.

3. Chemical Evolution of Our Planet

Several data coming from geo-chemistry and geo-mechanics have recently emphasized how tectonic activity is strictly correlated to the most important changes in the Earth's crust chemical composition over the last 4.5 billion years.[1,15] Ferrous elements (Fe, Ni) decreased by 12% and, at the same time, lighter elements (Si, Al, C) increased by 12% (Figure 4). In addition, alkaline-terrous elements (Ca, Mg) decreased by 8.7% and, at the same time, alkaline elements (Na, K) and oxygen (Great Oxidation Event[1,16]) increased by 8.7% (Figure 5).

Analogous perfect balances (precision of 10^{-3}) also hold with regard to the single geological eras and to the Earth's mantle.[1] Therefore, the various explanations based on element migration (towards the Earth center for the heavier elements and towards the atmosphere for the lighter) is not plausible, whereas the phono-fission transmutations are the only logically-founded and quantitatively-supported explanation.[17-20] Important considerations about carbon pollution[1,20,22-24] and the origin of water and the formation of oceans[1,21] can be made. Further surprising confirmations can be found even in the solar system, where Li depletion in the Sun[1,25] and the Ni-Fe balanced evolution on the planet Mars[1] can find simple and exhaustive explanations.

4. Electrolysis Experiments and Correlated Energy Aspects

Regarding electrolysis experiments, despite the great amount of experimental results, the comprehension of the energy excess still remains unsatisfactory. On the other hand, as reported by most of the articles devoted to the subject, one of the principal features is the appearance of micro-cracks on the electrode surfaces after the experiments. A mechanical explanation is proposed as a consequence of hydrogen embrittlement of the electrodes during electrolysis. The preliminary experimental activity was conducted using a Ni-Fe anode and a Co-Cr cathode immersed in a potassium carbonate solution (Figure 6).[26,27]

Emissions of neutrons and alpha particles were measured during the experiments, as well as evident chemical composition changes of the electrodes revealing the effects of fission reactions occurring in the host lattices. The symmetrical fission of Ni appears to be the most evident observation. Such reaction produces two Si atoms, or two Mg atoms, with alpha particles and neutrons as additional fragments.

In order to confirm the preliminary investigation, further electrolytic tests have been conducted using Pd and Ni electrodes.[28] As for the early experiments, relevant compositional changes and the appearance of lighter elements previously absent have been observed. The most relevant process emerging from the experiment is the primary fission of palladium (decrement of approximately 30%) into iron and calcium. Then, secondary fissions of the last two elements appear in turn producing oxygen, carbon and other medium-weight elements, as well as alpha particles (ionic He) and neutrons. The chemical composition changes were confirmed by four repetitions of the same experiment, always with very satisfactory ponderal balances. An extensive evaluation of the heat generation has been carried out showing a positive energy balance in correspondence to the major neutron emission peaks.

An incoming phase of the experimental research work is that of abandoning the previous pilot system and adopting a new pre-industrial prototype system.

5. Hydrodynamic Cavitation and Correlated Energy Aspects

Several laboratory tests have been conducted on hydrodynamic cavitation phenomena to evaluate particle emission, compositional change and heat generation.[29,30] The research activity was carried out using cavitators with different geometries, which were connected to a hydraulic circuit (Figure 7).

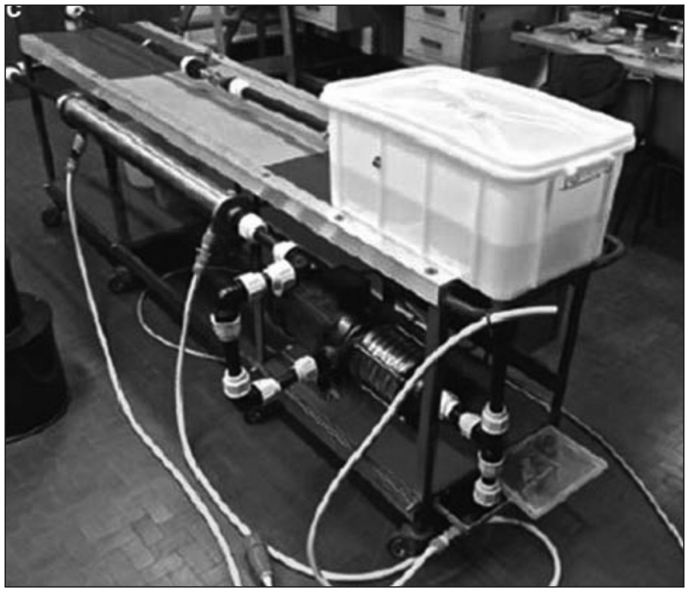

Figure 7. Hydrodynamic cavitation system: The hydraulic circuit and the centrifugal pump.

The most evident results obtained in the early experiments showed an increase up to one order of magnitude in the particle flux with respect to the environmental background. From the chemical point of view, the transmutation of heavier elements into lighter ones was observed in the water solution of iron salts.

As regards the energy balance, a coefficient of performance (COP) ranging between 1 and 2 was measured once the regime condition had been reached. Values higher than 2 were obtained using appropriate thermal insulation.

A further phase of experimentation concerned the study of the conditions of cavitation triggering. The implosion of micro- and nano-bubbles produced by cavitation is accompanied by the generation of phonons with frequencies up to THz.

This preliminary study highlighted the importance of designing cavitators able to maximize the generation of micro- and nano-bubbles. As a matter of fact, the dimension of the bubbles has to be considered a crucial parameter to control and increase the energy efficiency.

Optical methods, such as laser interferometry, could be used to evaluate the presence of nano-bubbles, thus providing important information to select the most efficient cavitators. This approach could allow the achievement of a COP greater than 4, which currently represents a competitive commercial target.

Also in this case, a transition to a pre-industrial system is going to be considered.

6. Terahertz Vibration Modes in Proteins

Proteins and, more generally, macromolecular structures are complex systems, which can be analyzed by means of different disciplines (biology, chemistry, physics, mechanics, etc.). Since strong correlations have been found between the biological functionality and the morphological characteristics of proteins, solid and structural mechanics concepts might provide important information concerning the behavior of these kinds of systems. In particular, the study of protein vibrations is essential.

Regarding living cells, the phono-fission reactions could explain the mechanism that governs the so-called "sodium-potassium pump" protein and, more in general, the metabolic processes. In the case of this ionic pump, the ions of potassium and sodium would be subject to a continuous and recurrent transformation of one into another, losing and regaining an oxygen atom at each passage through the cell membrane.

As cells are microscopic objects, so proteins are nanoscopic and the typical mechanisms of folding and unfolding, which make the passage of ions through the cell membrane possible, are accompanied by vibrational phenomena of resonance at the frequency of terahertz[31-35] (mechanotransduction[36]). More precisely, the folding changes of configuration in the proteins should be interpreted as phenomena of elastic instability in the dynamic regime. As in the case of acoustic emission from cracks or vortexes at the nano-scale, the resonance frequency of nano-structures may be evaluated in the terahertz range.

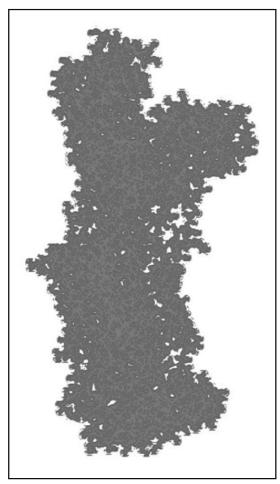

Figure 8. Numerical simulation of the vibration mode involving the Na-K pump protein.

Analogous reasons could also explain the "digestion" of radioactive isotopes intended as their transformation into stable isotopes of chemical elements which are essential for the vital activity of microbial cultures.[37]

Mechanical vibration in the terahertz range is believed to be correlated to protein functions. The modal analysis of the sodium-potassium pump macro-molecular structure can determine the low frequency vibration modes (Figure 8), which are in very good agreement with experimental results. As a matter of fact, these frequencies, being close to the Debye frequencies of sodium and potassium, could induce resonance phenomena in atomic lattices of such chemical elements.

Modal analysis is a useful tool for describing conformational changes which occur during protein biological functionality. The folding/unfolding phenomena may be investigated by means of nonlinear structural analyses of lattice models.

7. Continuation of the Present Research Work and Future Goals

The above described scientific results by the group of Prof. Alberto Carpinteri were achieved at the Politecnico di Torino in Italy beginning in 2008. In the context of the present proposal, the previous research directions will be continued and strengthened.

The large amount of experimental evidence is also supported by theoretical models reinforcing the idea that THz vibrations induced by mechanical instabilities (fracture in solids, cavitation in liquids and elastic instability in proteins) can trigger anomalous energy emissions and, at the same time, can explain all those phenomena that are not yet fully understood.

An interesting model used to simulate the phono-fission reactions was proposed by Norman Cook.[38,39] His approach is based on the lattice model of the atomic nucleus, assuming nucleons ordered in an antiferromagnetic face-centered-cubic (fcc) array. The simulations indicate that medium-weight nuclei can be split along weakly-bounded planes of the lattice structure.

On the other hand, Hagelstein proposed the phonon-nucleous coupling to explain the anomalies revealed in the fracture experiments.[40] In particular, the anomalies could be a result of the relativistic interaction between vibrations and internal nuclear degrees of freedom.

Further theoretical interpretations have been also proposed by Widom and Srivastava, who affirm that energy emissions and chemical transmutations may be related to piezoelectric effects and to the photodisintegration of the nucleus.[41] The electro-strong coupling between electromagnetic field and giant dipole resonance is fundamental for producing the observed anomalous reactions.

More recently, a possible unified approach was suggested by Lucia and Carpinteri introducing the plasmon-lattice interactions.[42] The next step could be a theoretical effort intended to understand the possibility of obtaining phono-fissions in the atomic lattice triggered by plasmon-lattice interactions.

In conclusion, considering the interdisciplinarity, originality and self-evidence of such experimental results and theoretical interpretations, a significant step forward can be performed in the full and unified comprehension of the following phenomena:

(i) fracto-emissions as seismic precursors;
(ii) progressive depletion of ferrous and alkaline-terrous elements, carbon pollution, ocean formation;
(iii) clean energy production from hydrogen-metal and cavitation systems;
(iv) THz-laser stimulation of protein functions (against cancer and degenerative diseases).

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