NANO DUST FUSION

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Abstract: After about 60 years of multibillion dollar efforts, the "official" versions of controlled nuclear fusion could not yield any results, despite all the efforts. Cold fusion did reach the overunity stage, though usually not in a reliable manner, except for the efforts of Rossi and Focardi, or Arata and Zhang. The Italian Rossi device seems to be ready for mass production. It looks like the original Pons-Fleischmann solution stumbled into the periphery of the right technical approach, like flapping wing-type airplanes at the dawn of aviation. The "gold mine" of controlled nuclear fusion parameters are to be sought at even higher temperatures, and by a different technical setup. The main arena of this effort is transient, dusty plasma of nano-size carbon particles supported by ion-acoustic resonances with hundreds of resonance peaks. The result is a reliable process having multiple nuclear transmutations.

Introduction

The process to be described is an unusual one. The essential ingredients are dusty plasma made from nano-size carbon particles and air and some water vapor (see Figure 1). In its simplest version the process works at atmospheric pressure, and at modest "lukewarm" temperatures at 1000 - 3000°C. The fundamental process could be created at home with most microwave ovens. Indeed there are dozens of demonstrations on YouTube, under the title "Microwave Plasma." However, there is a long and unfinished road from this easy demonstration to a practical device.

However, this method can be a faster road to a controllable, reliable, inexpensive nuclear fusion process. What sorts of fusion processes take place here? We don't know yet, but perhaps we will be able to answer the question with joint effort in a few years. It is obvious: there should be tectonic shifts in the approach towards controlled nuclear fusion theoretically and technically, in order to have a mass-produced device. The old "hot" fusion method and mindset should be abandoned, the sooner the better. That fruitless approach will not yield any technical result. However, the focus of the "cold" version of fusion should be shifted from bulk palladium electrolysis with deuterium at room temperature to higher temperatures, nano-size particles, without electrolysis. The nanoparticle-induced LENR pinpoints that this process is essentially a surface phenomenon, as indicated by David Nagel,[1] and *not* a process *inside* a lattice, as early theoretical models expected. Further, the phenomenon is not restricted to deuterium; ordinary hydrogen can serve as well, and even nuclei of higher mass numbers.

The Focardi-Rossi-type process of heated micron-sized particles is technically limited by the melting point of nickel. (There are similar problems with the Arata-Zhang-type of ZnO_2 + Pd nano-particles system, apart from the high price of Pd.) In our acoustic dusty plasma process we have two bottlenecks: the melting point of an acoustic resonator vessel and the recrystallization point of nano-size carbon particles. Otherwise, only the sky is the limit.

Part I: Fusion Device in Ten Minutes

The technical setup is as follows. As shown in Figure 2, the simplest device is essentially a household microwave plasma oven, where the essential fusion processes are restricted to the volume of an acoustic resonator. We believe the quintessence of the technical process takes place in the dusty, or "crystal" plasma.[2] The crystal plasma is essentially a "fifth state" of matter. It is plasma, though the small dust particles inside it are arranged along cubic or hexagonic symmetries as shown in Figure 1. The periodic, lattice-like crystal structure is not essential though; the nano-size carbon dust particles can settle in semi-organized "liquid" or disordered gaseous forms as well. Moreover, sometimes large voids of particles are formed within the oscillating plasma.

As shown in Figure 2, the dust particles have a large accumulated negative charge, as the high speed electrons bump into the particle surface, and penetrate deep into the dust. They remain trapped until an extraordinary high electron density is reached in the order of 10^5 - 10^9 electrons/particle.

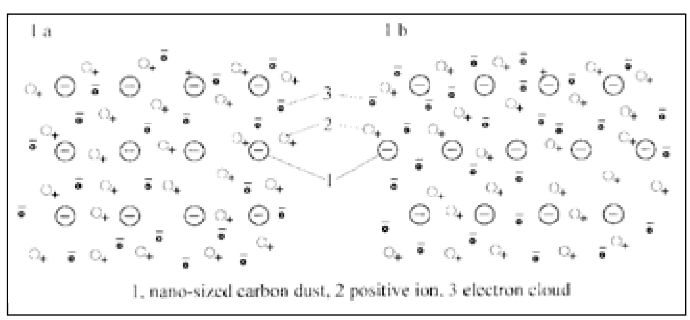

Figure 1. Schematic view of near equilibrium rectangular crystal (or dusty) plasma. Small micron or nano-size negatively charged dust particles are in dynamic equilibrium with the neighboring plasma. Positive ions are attracted to the surface of the dust particles; they may take an electron and leave it as a neutral atom or oscillate collectively on the surface. This configuration is a dissipating, energy-consuming media, of no direct practical interest. The particles can be of any shape, and their distribution of size is usually non-uniform.

In order to have a very high-speed (near the velocity of light) seeding electron cloud, the plasma must oscillate at a wide spectrum of frequencies and at very high amplitudes. The "plasma wakefield acceleration effect"[3] is to be used for the "seeding" process. It is analogous to surfing on the beach. When a steep and emerging wave approaches the beach, the "cloud" of surfers riding it is accelerated, extracting momentum from the huge kinetic energy of the wave. A similar effect is used on smooth water, if a motorboat is towing a water skier. There is no need for a rope; the V-shaped wakes can propel a skilled skier maneuvering on the inner slope of the boat wake wave. Tabletop-size plasma accelerators are able to produce up to a 1 GeV/cm electric field in a plasma wave. This is more than any giant, kilometer-sized accelerators of Fermilab or CERN are able to produce (but the beam is not uniform in our case).

The processes inside the plasma are indeed complex. Apart from the nano-size carbon dust particles, negative and positive ions, electrons and neutral atoms or molecules oscillate in a resonator, in order to achieve many frequencies with the highest possible amplitudes.

Though microphones cannot be inserted into the plasma, nor into the electromagnetic resonator, the amplitudes are believed to exceed 130 dB, fortunately most of them at the ultrasound range. Unfortunately, there is another peak of intensity as well for the infra-sounds at the range of about 10 - 20 Hz, as this is the typical hallmark of dusty plasmas.

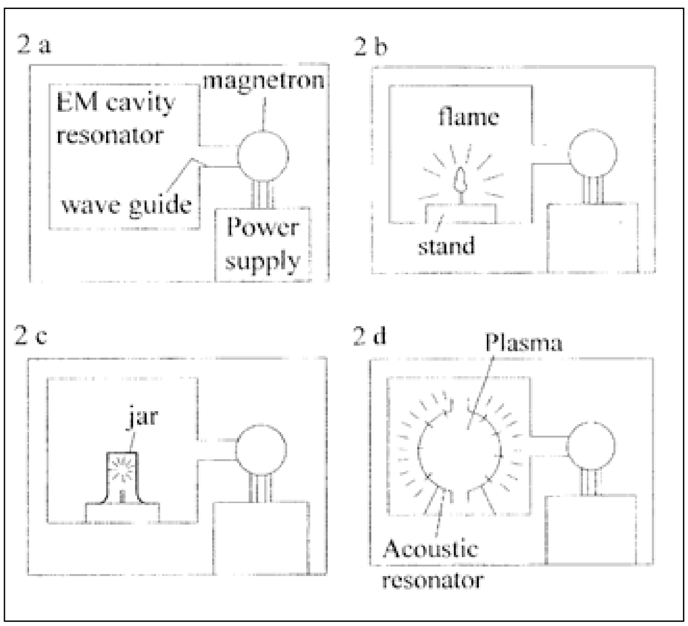

Figure 2. Schematic layout of a microwave-driven dusty plasma experiment setup: a) Layout of a commercial microwave oven. The metal, rectangular cavity resonator has a strictly calculated geometry. (The waveguide and the magnetron are not detailed!) b) A burning, pointed wooden stick is placed on an insulating stand. After the door is closed and the magnetron is started, a shiny loud humming plasma blob is created, and it will float to the ceiling, melting it after awhile. A thin sharpened graphite rod will do the same job. c) When the stick or a graphite rod is covered with a glass jar, the effect is better, louder. The jar is broken after a few seconds, due to thermally-induced mechanical stress. d) Spherical, tuned quartz acoustic cavity resonator inside a metal EM cavity resonator. The latter should be modified (along the wave guide and the magnetron electronics) to yield an optimum ($\cos \varphi \approx 1$), and high performance. When dense CO_2 is blown into the acoustic resonator, the break-even point is exceeded by a wide margin.

In order to satisfy the instant curiosity of the reader about the device, Figure 2a and 2c provide a quick introduction to the essentials of a small "home-made" dust fusion reactor. Figure 2a is a simple microwave oven, where microwaves are radiated into the EM resonant cavity via a waveguide. One has to place a match or a thicker pointed peg of dry wood into the center. Light it, then close the door quickly, turn on the oven (at about 1 kW), and watch a shining flame climb up to the ceiling. This is the crystal, dusty or complex plasma. The soot particles of the burning stick of wood provide the micron or nano-size carbon particles. It is even better to use a thin, sharpened graphite rod, taken from a mechanical pencil.

A further step is shown in Figure 2c, where the plasma blob is captured in a glass jar. This is the end of the foolish YouTube type experiments. A real qualitative, but very difficult step is to use a spherical quartz resonator with at least two different tubular elongations on the top and on the bottom of the sphere. It should be placed on an insulating stand. A proper, well-tuned acoustic resonator, and a properly matched impedance chain starting from the magnetron to the EM cavity, is a must. The difference is like having a violin without the usual resonator, or to have a piano, but without the wooden soundboard, only the strings. Instead of a spherical quartz resonator, one might use an open-ended quartz tube (~25 mm x 60 mm) or a 50 x 50 x 50 mm box made of mica plate (see Photo 1).

The system is not necessarily closed hermetically, as it works at atmospheric pressures, or at higher and lower pressures as well. There is another unique feature of this system: it is extremely tolerant of any "alien" matter passing through the plasma. Thus a very wide range of chemical and nuclear reactions of fusion of the plasma can be achieved, like splitting the molecules of CO_2 or any hazardous materials like waste rubber tires, or galvanic sludge, just to name a few. Electrochemical cold fusion cells are intolerant of any garbage or pollutants getting into the electrolyte or into the electrode material. The system in Figure 2c is enough for a "breakeven" device, if dense CO_2 is blown through the plasma inside the acoustic resonator.

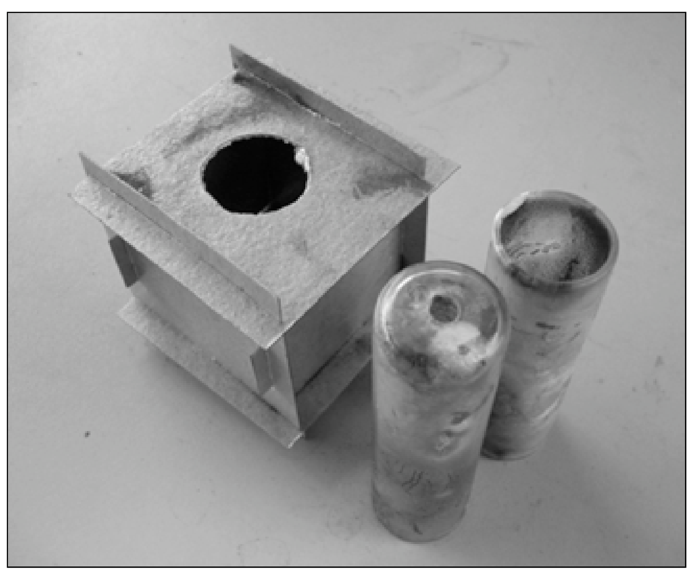

Photo 1. Makeshift resonators: Mica box, tubular quartz resonators: half wave when both ends are open, quarter wave when one end is closed.

Part II: Assumptions

God Created Matter, but the Surface is Made by the Devil

What sort of physical process takes place inside the plasma? The unique and very embarrassing feature of this particular technology is that the essential phenomena take place simultaneously at least on four different levels of size and time scale, spanning about 12 orders of magnitude. These are the following:

1. Macroscopic – engineering level

Complex plasma oscillations of different frequencies range from the order of 1 Hz to GHz. Consequently, the wave lengths of acoustic oscillations vary from the scale of centimeter way down to submicron. When filmed by a high-speed camera, the different oscillating regions are visible to the naked eye, up to a limit. On some films one can see an oscillating spherical "checkerboard" with regions moving in and out of phase with regular-size subregions like the surface of a peeled orange. The dusty plasma as a whole is considered to be electrically neutral, except its surface.

There are ostensibly similar differences in the local plasma temperatures for different ingredients. Electrons, accelerated by the mechanism of plasma "wakefield acceleration" can reach nearly the velocity of light, therefore they can penetrate deep into a dust particle, creating an enormous charge density never seen in any other technical device.

In fact, the acceleration of even a positive ion can exceed that of a black hole beyond the event horizon due to the massive negative charge of a dust particle. But for neutral atoms near the cold wall of the acoustic resonator, the velocity has modest, usual values like in any technical device (like a welding torch).

2. Micrometer range

This is the level of the interaction of the carbon nano-particles with their ambient surroundings. The plasma is no longer neutral electrically in this range. The non-linear Debye length is the characteristic distance of the dust-plasma interactions.

The dust particles are of micron size at the start, but by the time they reach the working plasma temperature they are broken and re-grown into nano-size pieces by evaporation, condensation, crystallization, erosion and Maxwell stress rupturing due to the repulsion of the electrons accumulated inside the dust particles. Small "fullerenes" and sections of nano-tubes are to be found here, as these particles pass even through very fine filters.

Remember that without the fine nano-dust of right size and shape there is no effect whatsoever. (Plasma etching, or ion bombardment, also creates such small particles, as a frequently cursed side effect of semiconductor chip manufacturing and ion implantation, but of Si.) The regular features of this dust lattice crystal, or liquid seem to be essential to its success. This lattice can accommodate transverse, longitudinal and even torsional oscillation, and it can amplify them via resonant effects. A simplified sketch of the "dust acoustic resonance," or dust acoustic wave, is shown in Figure 3. The characteristic feature of this wave is that the heavy carbon nano-particles are relatively *stagnant*, and the electron cloud is mobile. The electron cloud is driven partly by the external electrical field of the transversal waves of the magnetron, and by the self-organized plasma oscillations. The positive ion cloud (mainly of N^+) and the negative ion cloud (mainly of O^-), and the negative carbon nano-particles, are the dominant "masses" of this oscillation. The elastic "spring" is the electrostatic field of the ions and nano-particles. This nonlinear oscillation is characterized by a large number of resonant frequencies, and only a few of them are audible. Most of them are in the ultrasound range (from 20 kHz up to some GHz) with regular distribution of peak resonant frequencies. (This qualitative distribution is shown in Figure 4, up to 100 kHz.)

3. Nano-meter level

We have arrived down to the time and size scale of parameters, where the usual macroscopic rules are no longer valid,

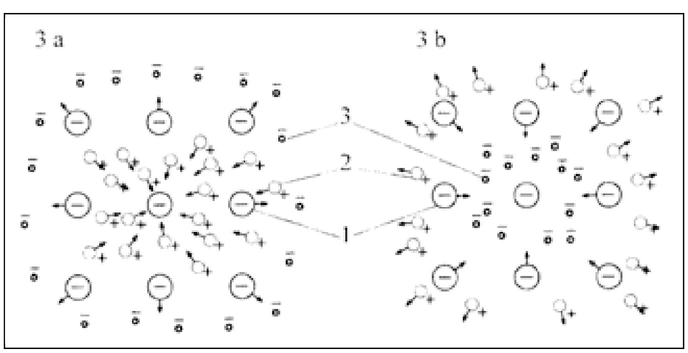

Figure 3. Simplified schematics of a dust acoustic wave, for two characteristic positions: when the electron cloud is inside (3a) or outside (3b) of the dust lattice. The dust lattice itself barely moves, but the positive ions (and negative ions) and the electrons do move. They interact with the external microwaves. Only the fundamental harmonic is shown, not the sub and higher harmonics. The plasma is strongly nonlinear and self-organizing. The resonator wall is not shown.

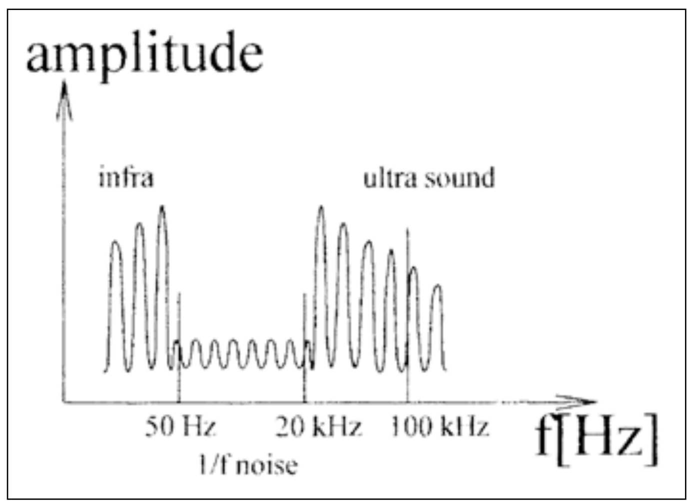

Figure 4. Characteristic distribution of acoustic amplitudes (in logarithmic scale) as a function of frequencies (linear scale). This is the least expensive plasma diagnostic tool. Under about 50 Hz, the dust acoustic waves are dominant (infrasounds). There are no dominant peaks in the lower audible range. High peaks appear in the ultrasound region, due to ion acoustic oscillations. The higher and narrower the resonant peaks are, the better. The sphericity of the acoustic oscillator is the most important quality factor. Over 100 kHz Tesla wave detection could replace acoustic plasma diagnostics. Some test data are as follows: 3 Hz 68 dB; 5 Hz 72 dB, 12 Hz 98 dB; 3200 Hz 81 dB; 6400 Hz 80 dB; 12800 Hz 82 dB; 25600 Hz 72 dB; 32000 Hz 62 dB; 38400 Hz 62 dB; 89600 Hz 56 dB. (Data was taken outside of the metal EM cavity resonator.)

yet the rules of the familiar quantum mechanics cannot be applied. For example, gold nano-particles are chemically reactive, and most materials significantly change their physical properties, like melting point, electrical conductivity, magnetic properties, etc. Surface effects become dominant to those of the lattice or crystal structure. Entirely unexpected qualitative and quantitative features emerge already at this size level. Weird quasi-particles appear at this size scale. They have properties technically useful yet not utilized.

On the surface of the dust particles "surface plasmon polaritons" rule the local world. They are unusual phenomena, little-known, studied by only a handful of physicists. Quasi-particles like electron "holes" in a semiconductor crystal, spinons, excitons, or quantized phonon vortices, etc. are strange but useful objects. Magnetic monopoles have also been discovered (and eventually forgotten) the same way. (A charged, rotating magnetic dipole of micron size irradiated by light behaves like a perfect quantized magnetic monopole.[4])

The most ancient and well-known "quasi-particle" is a surface wave that carries energy by collectively organizing individual droplets. Yet it came as a surprise in the 1880s that these objects can be nearly dissipationless.

Contrary to magnetic monopoles, surface and volumetric plasmon polaritons have not been forgotten.[5] These quasi-particles appear even on infinite metal/dielectric surfaces. They propagate electron density waves, or electromagnetic waves, strongly bound to this interface. The electric field intensity at the interface can be very high. There can be even resonant field amplification at small nano-size conductive particles, whose size is smaller than the wavelength of the exciting source. The excitation sources are particle impact, optical waves and near field effects. The mid infrared wavelength range is especially favorable.

Surface plasmon effects can be more prominent on nano-size conducting particles than on optical grades or metal plates. Good conductors are Au, Ag or multi-wall conducting carbon nano-tubes, which produce pronounced field amplification effects, especially in the presence of plasma, which has a negative complex dielectric constant.

As conducting multi-wall nano-tubes are about 1000-times better conductors than copper or silver, their presence is a must. They can be quite easily "manufactured" in high-pressure oscillating reactive plasma.[6]

Due to the pronounced resonant field amplification, all sorts of high-energy effects forming neutral particles may take place there like those proposed by Mills.[7]

Collectively oscillating electrons may interact with positive ions and protons, thus forming neutrons. The setup is the perfect match to the model developed by Widom and Larsen.[8] Ultra-cold neutrons or other neutral quasi-particles can be born by these interactions, then react with any nucleus they can contact.

This process is most likely *not governed by strong forces*, but ostensibly by electroweak interactions. Thus the collective oscillations of surface electrons do not necessarily cause fusion by strong interaction, but the rest of the process might cause fusion. So this very strange group of phenomena is most probably restricted to the surface of nano-size carbon particles. Unfortunately, there is no way to directly observe and judge the ultra fast reactions on the surface of the carbon dust, but without dust there is no effect. This effect dominates the outer layer in the resonator, shown in Figure 5.

This is essentially a non-radiant phenomenon. No radioactivity is detected when the input power density is

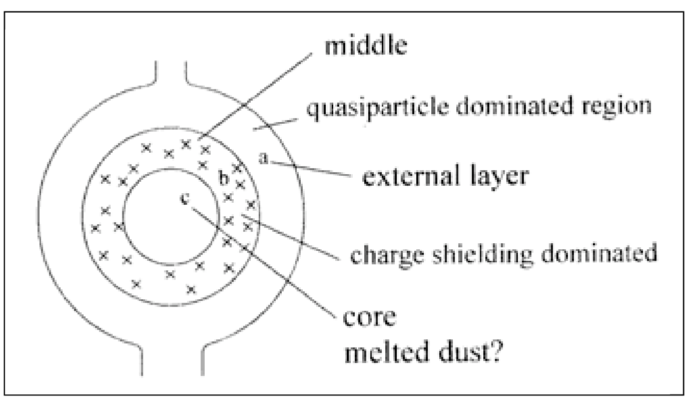

Figure 5. Schematics of the visible plasma characteristic for slow motions for a 10 cm diameter acoustic resonator, for about 1.5 KW input: a) The external plasma near to the wall is the coolest. Moving nodes, antinodes and crests (being darker) are clearly visible, and produce Chladny-like surface oscillations. (The characteristic physics seems to be dominated by quasi-particles.) For low input energy this is the only visible mechanism, and there is no radioactivity. b) At higher input energy, the sparking region appears, along a mild degree of radiation—both X-rays and particles. (There is a slight radioactivity in the exhausted dust and the quartz sphere after the power is switched off, for a couple of days.) c) Internal core—no information. Melted nano dust particles?

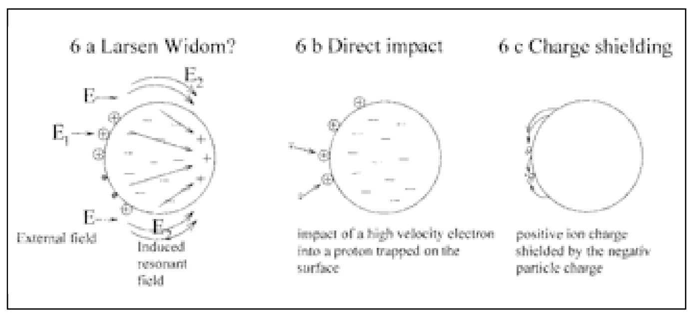

Figure 6. Three different assumed mechanisms take place on the surface of nano particles. a) Due to the external transversal and longitudinal E_1 electrical field, the conductive dust particle (nano-tube) is unevenly polarized. A secondary, amplified E_2 electrical field is generated, and it is very strong. The field amplification factor could be up to 10^8 [4a]. In the strong E_2 secondary field, protons attached to the particle surface are accelerated, and they may form neutrons with the electrons (Widom-Larsen process?). Ionized argon atoms may take part in a catalytic reaction with electrons (Mills process?). Small closed carbon spheroids may be used, from fullerenes (C_{60}) up to carbon spheroids of C_{540} may participate in this process, but mainly nanotubes are present. Even single-layer graphene flakes can participate in this type of process; their sharp edges and good conductivity are essential in this type of the process. b) When the dust particle is not yet fully charged, an electron, accelerated by plasma wakefield acceleration (up to 0.6-0.8 GeV) hits a proton on the surface, yielding a neutron (Widom-Larsen II electro-weak interactions?). Large, closed-surface carbon spheroids and amorphous grains of up to 10^6 atoms may take part in the process. c) The charge shielding effect can be substantial with very high dust charge density. Protons or deuterons can take part of reactions involving strong nuclear forces. Region 'b' in Figure 5 yields radioactive by-products. Larger particles of several layers of carbon atoms, even amorphous micron-sized ones, may take part in this process. Electrical conductivity is not essential; the larger the particle, the more charge can be accumulated, until it is ripped apart by internal Maxwell stress.

kept under a threshold level of plasma volume (of about 1 kW/1 dl). When the power density increases, radioactive radiation appears, *e.g.* mild X-rays, β and γ radiation.

4. Electron, nucleon-size level

Here the more or less familiar rules of quantum mechanics, or QED, rule. In our opinion, strong interaction and "classical" fusion start to dominate the process above a certain power density in the middle layer. Sparking is visible on slow motion films. Obviously, the amplitude of oscillation also depends on the plasma radius, pressure and temperature. At the center of the plasma, the amplitudes should be much higher than those at the outer wall of the acoustic resonator. (There can be the highest amplitude of a spherical standing wave.) See Figure 5 for the three layers.

Near the center of the plasma sphere (middle layer), charge shielding can dominate nuclear processes due to the enormous surface charge density of the dust. Then repulsing charges of like protons can be overcome by the huge negative charge density of the carbon particles.

On the slow motion video recordings, one can clearly see the appearance of sudden small sparks, *en masse*. Then the Geiger counter starts to click, though at moderate levels. At present no one knows what goes on in the center of the acoustic resonator.

In Figure 6 these simultaneous mechanisms are shown as field amplification by resonant surface polaritons (6a), direct volumetric polarization by electron and ion impact (6b), and charge shielding (6c), where strong interaction rules (again at a different size level) at the characteristic size of a nucleon. Obviously these are all hypothetical mechanisms, as they cannot be observed directly.

Several "classical" fusion reactions and other new types of fusions involving heavier nuclei may take place here. The surface of the carbon dust particle creates a nuclear active environment, using the wording of Edmund Storms.[9] The key words of this new arena of "nuclear active" environments are: dusty, resonant plasma, nanotechnology, surface and volume plasmon polaritons, electron loading, crystal plasma, microwave excitation, or RF excitation. Technically this is the "hottest" of the "cold" fusion processes.

The classical Pons-Fleischmann process takes place mainly a bit above room temperature, with a palladium cathode, and heavy water (D_2O) electrolysis. Though there are other sub-fields, they are variations to this engineering setup. This is the most widespread and even most investigated "theater of war," but after about 20 years of investigation, there is no mass-produced device based on this setup, though initially it was very useful and influential. The high-temperature ceramic proton conductor experiments of T. Mizuno have been the exception, not the rule.

The Arata-Zhang or Focardi-Rossi-type (or Mills?) of micro-powder and nano powder approach, with H or D loading at about 300°C, already promise practical application. The resonant, dusty plasma, based on carbon dust can be another "battleground" that can yield other useful technical applications, and offer a reliable, inexpensive nuclear process.

But it comes at a price. Many new, hitherto unheard physical effects need to be combined and utilized due to the complexity of self-organizing resonant dusty plasma. However, this is the least explored, least understood group of phenomena. Apart from reliability, its most important advantage is that it allows the simultaneous presence of several types of energy-generating nuclear phenomena, layer-by-layer, as shown in Figure 6.

There are at least four different size scales and five different physical phenomena to be watched simultaneously. Dust ion-acoustic resonances driven by resonant transversal and longitudinal electromagnetic waves (crystal plasma oscillations), surface plasmon polaritons (as quasi-particles), wakefield electron acceleration (and electron penetration into a dust particle), and charge shielded "normal" and neutron-induced fusion processes may take place at different intervals of time, scale and temperatures.

Unfortunately all theaters of actions must be observed simultaneously, and should be understood at least in their essentials. Simultaneous embedded, serial electromagnetic, acoustic and polariton resonances, and field amplifications, are essential to have a practical device.

"Cold fusion" or LENR is used here as a wording only in its broadest sense, as several plasma-based interactive phenomena take place simultaneously. The possibility of Hagelstein-type processes should be considered as well, as the characteristic frequencies can be of Terahertz order, due to intensive infrared radiation.

The phenomena based on dusty (crystal) plasma are non-equilibrium, non-linear, self-organized, complex phenomena. Essential effects take place at all four levels, but all of them are interconnected via several internal feedback loops.

The exact description of the internal positive and negative feedback loops and their consecutive relations are as yet in the fog of our ignorance, and will remain so for awhile, as their interconnectedness is sometimes loose, sometimes strong. For example, the energy generated by electroweak and strong interactions directly influence the average plasma temperature. However, "average temperature" is a parameter of interest for an investment bank only who want to know nothing but the average excess power density. The electron temperature, and the positive and negative ion cloud temperature, are of interest only as a function of space

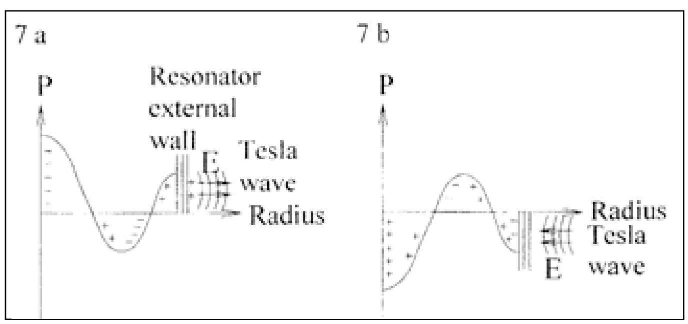

Figure 7. Two phases of a dust acoustic oscillation. The heavy dust particles do not move significantly, but the electron cloud does, partly as a consequence of wakefield acceleration. Positive and negative ions may also accelerate to a much lesser degree. (Neutral atoms, molecules are not shown.) Only the fundamental frequency is shown. The excess heat is generated on the surface of the carbon nano-particles by heating a wave, thus creating a positive feedback. Tesla waves are emitted from the plasma surface, as the surface charge alternates from positive to negative. The external electromagnetic radiation is absorbed mainly by the electrons. The thickness of the plasma sheet absorbing external and excess energy depends on the number of free electrons in a given volume. This restricts the maximum diameter of an acoustic resonator.

and time. Who can provide this? Not to speak of the amplitudes of crystal plasma dust oscillation. Moreover, all of these should be coupled to the incoming transverse waves and to the partially reflected longitudinal (Tesla) waves generated on the surface of the plasma.[10]

As we cannot dissect this phenomenon to separate sub-effects (and thus simplify the process), we can study this group of effects like a botanist, just watching it grow by slightly altering the ambient parameters.

Self-organization makes the process of chaotic plasma and the device simple, durable and inexpensive. On the other hand, complexity makes the experimenter mad, as seemingly small changes in size and shape usually make significant and fatal changes in the behavior of the process.

Diesel engines serve as an example. They produce both plasma oscillations and dust particles, but no crystal plasma and no lattice-induced nuclear phenomena. These machines have been manufactured by the millions, and for over one hundred years. Still the development is not over yet. U.S. automakers are unable to produce high-quality, small and inexpensive diesel engines (like that of VW), but they are capable of making excellent, large truck engines. This is just an example of the need for the immense amount of know-how during the R&D phase. This is the "dark side" of the force.

Part III: The "Dark Side" — Engineering Problems

As we have realized quite early, there is simply no room here for elegant mathematical modeling. There are nice (and unsolvable) equations for crystal plasma, polaritons, nuclear phenomena, etc., but without constitutive relations, proper initial and boundary conditions. To make things worse, there are no proper inexpensive plasma diagnostic tools to check the validity of the calculations.

Few people are aware of the immense efforts of the complexities of the dusty diesel plasma diagnostics, for example by X-rays. Millions of dollars have been invested into this R&D, but it has not yielded results. Experience, immense accumulated knowledge, intuition and trial-and-error type efforts characterize the development of plasma devices.

The same happened during the formative years of the mass production of microchips. The presence of silicon dust has been observed early during the plasma etching process. It was assumed that it came through the window. Therefore expensive "clean rooms" were built, and cumbersome safety clothing had to be won. Yet it was a mistake. The dust was an unwanted and annoying side-product of the plasma etching process. By the time it was realized, hundreds of millions of dollars were wasted on unnecessary expensive dust filters. (Nevertheless, medical operating theaters benefited from the advanced filter systems.)

It is strange that tokamak-type hot fusion projects consider the carbon dust in the plasma as an annoying process to be eliminated at any cost.[11] Carbon inner tilings of the toroidal chamber have been replaced by tungsten tilings. There is a sophisticated solution to mitigate this problem (the divertor chamber). However, the dust is the solution to have controlled fusion, and the problem which needs to be mitigated is the ITER.

For our experiments in nuclear reactions assisted by resonant crystal or dusty plasma, the age-old trial-and-error method was the only way forward. Science relies on and revels in intuition, hard work and pure luck. Therefore this kind of science is mankind's last hope. Science as an institution always suppressed and will keep on suppressing it, to our greatest peril. All this was necessary to mention before we discuss our test results and further details of the devices, which have always been based on intuition, crude diagnostics and never on detailed calculations. We have to mention that only a fraction of the desired tests were carried out, due to lack of funding and consequent lack of man-power. We have faced major difficulties with several technical issues at the same time.

The first challenge has been the efficient generation of high frequency EM waves, to find out the right shape and size of cavity resonators, coupling antennas and waveguides. There was very little "off-the-shelf knowledge" in this field.

As we realized to our peril, the resonant, oscillating plasma emits scalar, or longitudinal (Tesla) waves.[10] Textbooks on electromagnetic waves mention only transversal waves. Some of them try to give a shy explanation of why there are no longitudinal and torsion waves. As any textbook of mechanics describes these waves in solids, the longitudinal (sound), transversal and rotational waves, one may ponder where they are in electrodynamics. The trouble comes mainly from the fact that Tesla's pioneering research in this area has been almost completely ignored. The fundamental process to generate a longitudinal wave is to charge a sphere (or a plate) to a high electric potential, and to discharge it rapidly. It is better to have one-sided "push" waves, but the push-pull method also works in an oscillating membrane. According to our visual observations, the plasma has even rotated in the cavity resonator. According to textbook physics there is no reason for it to do so.

The rotated plasma phenomenon appears at the threshold level of several thousands of volts and kHz. In our oscillating plasma, both the negatively charged dust particles and negative and positive ions take part in this oscillation process (see Figure 7).

Without heavy positive and negative ions, there is no ion acoustic resonance, and there are no significant oscillations. Electrons are simply too light to counterbalance the heavy mass of positive ions. Nevertheless, ion acoustic and dust acoustic oscillations have a very useful property: they emit longitudinal sound and Tesla waves, which serve as a reliable diagnostic tool, along with the spectrum of the plasma (though only for a narrow band for acoustic frequencies).

The Tesla waves are emitted from the plasma surface. However, the cavity resonator, which is reflective for transverse waves, is only partially reflective for the longitudinal EM waves, which is an unwanted loss along with the generation of sound waves (see Figure 7). This posed a major drawback for us. The electromagnetic cavity resonator has to be optimized to achieve the following triple task:

1) At the start, an ignition pack of carbon powder is placed into the acoustic cavity resonator, and this resonator is placed into the transversal cavity resonator (see Figure 2c). The dust lump must be located at the maximum node of the electric field, otherwise there is no ignition. Only transversal EM waves are present.
2) After ignition, the conductive plasma destroys the high-quality factor of the EM resonator by short circuiting, and

dissipating. Then a different shape of transversal wave cavity resonator would work more efficiently. So we struck a compromise: we start at a higher input power, but once the plasma is formed, the input power is reduced.

3) However, when the temperature of the device has climbed to its normal steady value, the power partially radiated away by scalar longitudinal (Tesla) waves is annoying. The Tesla waves are generated at multiple frequencies, as they are generated by the ion and dust acoustic waves. Therefore their multiple reflections and transmittance inside the EM cavity resonator require a different shape than that of transversal waves only. In the beginning, the performance of the new box was not steady. Sometimes it was self-extinguishing, when the match between the shape of the "metal box" (EM cavity) optimized for transversal and longitudinal waves and the position of the acoustic resonator (quartz sphere) was not correct. It took an extreme amount of trial and error to figure out a compromise among the three competing design criteria.

Longitudinal (Tesla) waves are emitted by the plasma (by a complicated spatial distribution at the maximum amplitude nodes), and reflected back into the EM cavity resonator. If the longitudinal wave is reflected back partly into the plasma, then a positive feedback loop exists, and the plasma is self-sustaining. See Figure 8.

Otherwise there are two competing modes inside the metal cavity resonator (because the two EM waves have two different nodes) and the oscillation becomes intermittent, causing a series of flashes and loud mini-explosions. These events are technically useless.

The arduous task of optimization for the longitudinal and transverse waves was solved by one of our staff by trial and error. He kept on building and testing new cavity resonators, always rectangular ones, as they were easy to make and relatively inexpensive. The spherical acoustic resonator made of quartz serves for the plasma. However, there is a significant energy loss due to sound energy. So the transversal longitudinal EM cavity resonator also functions as a simple external acoustic resonator. Still the rectangular shape is not good enough; a spherical one would be better. Certainly there is a huge range of untested geometries: cylindrical, spherical or semi-rounded cylindrical. As a rule, the acoustic and the EM resonators do not have a common geometrical focus point. The acoustic resonator usually ignites there, but not at optimal parameters.

All musical instruments were developed during the Middle Ages and modern times by this trial and error method. Think of the analogy of a violin or a piano. The wave generation starts with the "ignition" of strings, but their impedance matching to the ambient air is simply awful. Even harps have a small impedance matching resonator. (Otherwise they could not be heard even from a short distance.) The impedance matching between the power source, the bow and the chords, the bridge, the resonator and its structure is more than pure physics, it is empirical art.

A violin built long ago by Stradivari or Guarneri is still very expensive, though its technology is better understood and more sophisticated now. The difference between a master violin and a mediocre violin appears in the richness, the density of harmonic transversal waves of the resonator. Therefore the quality and the preparation of the structural wood material was a trade secret (and still is).

The sound gets better and better as more input energy of the artist is transformed into the delicate balance of properly selected longitudinal and surface mechanical transverse (bending) waves, which turn into secondary longitudinal sound waves. This serves as a useful analogy between the two types of devices. See Figure 9.

The difficulty to have instant success is really discouraging. One has to be extremely patient and diligent to map the acceptable working parameters. However, this is a fair deal, as there is a reward from an unknown corner.

Longitudinal (Tesla) waves of different frequencies tend to destroy some bacteria and viruses, but only at a rather sharp range of frequencies. The honor goes to Raymond Rife, a prolific U.S. inventor and physician. He used hydrogen gas plasma acoustic oscillations to study the medical effects of Tesla waves, as Tesla himself did. He was able to cure flu very efficiently, and some types of cancer as well, as a virus infec-

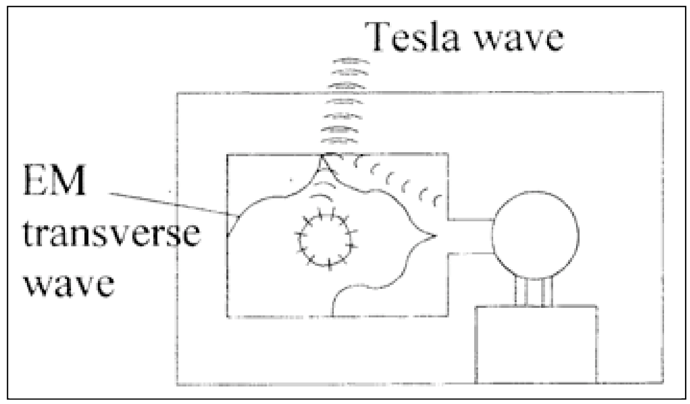

Figure 8. Outline of the process of the generation-reflection of Tesla (longitudinal) wave. Net charge (positive or negative) appears on the surface of the plasma sphere (see Figure 7) creating a net surface electric field of changing sign, thus longitudinal waves. There are a number of frequencies for the longitudinal waves, which are partly reflected, partly transmitted by the metal EM cavity resonator. There is no clear-cut geometry for high Q cavity resonator for the longitudinal waves, so its resonance curve is short and flat. Powerful longitudinal waves may destroy the magnetron. Three embedded resonances are shown here. Electromagnetic (transversal and longitudinal waves), acoustic and (invisibly small) resonant surface plasmon polaritons. The last one is essential.

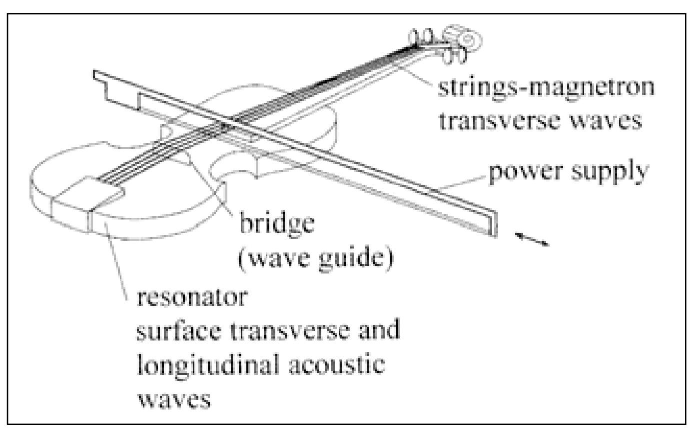

Figure 9. A simplified "string" musical instrument. Its strings can be excited by a bow or plucked by hand. The energy of the transversal waves is led by a bridge (wave-guide) into a resonator, which is an acoustic cavity.

tion could lead to malignancy (after some decades) when the immune system is weakened. This effect has come to us as a surprise, after our friends witnessing the ongoing plasma tests were cured from colds or mild flu.

Nevertheless, over certain large doses of weeks or months harmful effects appear, like nose bleeds or nausea. The Tesla waves may irritate the polarized surface of the cell membranes of the nose.

Certainly we do not want to diminish further the poor respect for cold fusion research. Possible titles like "Mad Scientists Claim to Kill Bugs by Cold Fusion" would not help this field, though the useful medical potential is definitely there.

Part IV: The Next Hurdle

The proper shaping of the acoustic dusty plasma resonator is a similar problem. Without this acoustic cavity resonator, the efficiency of the process is meager. This is not a surprise. At the dawn of radio and TV, the signals were so weak that selective amplifiers, several filters and resonating circuits had to be invented during the dawn of the analog radio age, both for transmitters and receivers.

In light of these routine engineering considerations, it is strange that "mainstream" hot fusion devices do not use resonant effects. Brute force gives birth to inefficiency, thus a poor product on the market, or stalled research.

The importance of acoustic resonance for the amplification of the amplitudes of plasma oscillations is obvious. It was clear from the start that the efficiency must be increased. However, the proper design and manufacturing of this Helmholtz-like cavity resonator is not at all simple.

We have used at least two circular holes with some edge rings on the top and bottom of the spherical resonator. The material is quartz, as spherical heat and stress resistant ceramic shells are not available off the shelf. Certainly, this is a severe restriction, as quartz breaks and partially melts at about 1400ºC. (Further, only a few elderly glass blowers are able to form quartz with the required accuracy.) Unfortunately even 1-2 mm deviations from sphericity hamper efficiency due to severely diminishing amplitudes. More than one hundred quartz acoustic cavity resonators of this type have been built and tested, being the most expensive part of the project. The rejection rate of the glass spheres is more than 50%. About half of the spheres have given acceptable results, the rest went to the dustbin.

The evenness of thickness of the walls, lengths and diameters of the rims, and the ratio between the diameters of the holes was important and required painstaking patience. It is necessary to have two holes and rims of different geometries. If only one hole is used, it yields only a few peak amplitudes, some fundamental ones. Two (or more) holes give more frequencies, and their sums and differences also appear, as the plasma is nonlinear. In a sense, the resonant quartz sphere is a musical instrument. Optimization is important. It seems that the sequence of frequencies and their amplitudes significantly influence the performance of the process. The more resonant peaks we have, the more the efficiency increases, but so does the sound pressure (the amplitude). However, the larger the area of the rimmed orifices (see Photo 2), the smaller the (relative) amplitude is. (One can measure the sound intensity only outside of the hot metal cavity resonator, not inside because the microphone would melt).

Most of our work has been devoted to the optimization of the two cavity resonators, and yet it is far from being perfect. A team of at least five to six members could most probably do it in two or three years. Apart from this, the dusty plasma oscillations also contain novelties, as there is a single driving frequency (magnetron) and hundreds of resonant peak plasma frequencies.

The diameter of the sphere, the geometry of the two or three rimmed tuning holes (or short tubes) and the average plasma temperature (the driving power) all influence the outcome. For the interested reader, much is needed to be learned about the synchronization processes.[12]

But in order to avoid the expenses of quartz manufacturing and the hardly repeatable hand-blown spherical acoustic resonators, one can decrease the pressure. An oil-free rotary pump is enough; then less expensive and even tubular-shaped Pyrex tubes can demonstrate this phenomenon. However, the vacuum system pressure gauges, and the thicker metal cavity resonator, add to the costs and troubles.

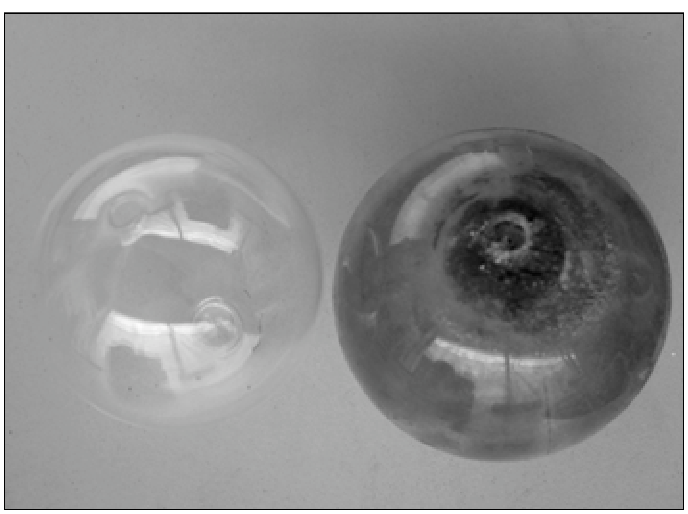

Photo 2. Spherical quartz resonators, diameter about 6 cm.

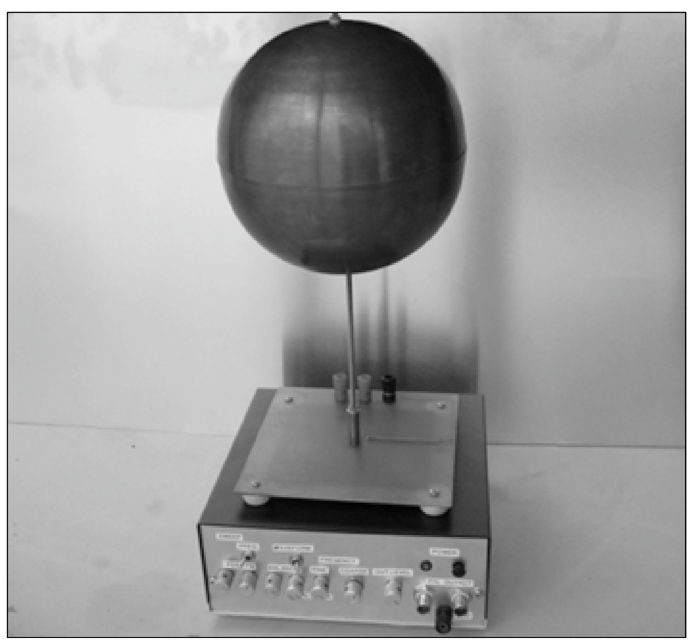

Photo 3. Tesla-wave generator for calibration 100 Hz -1 MHz.

All the above-mentioned seem nothing but complaints, but one has to learn from the hostile reputation of the original Pons-Fleischmann experiments, when the immense amount of the minimum required know-how was simply nonexistent at the time of publication.

Our devices and process require even more know-how. To start from scratch without a lucky strike is suicidal because there are so many opportunities to fail.

Several resonant phenomena have to be matched carefully for optimum performance, and a vast amount of first-hand experience is necessary, as there is very little reliable know-how in this field. The reward will be a reliable, powerful effect with a modestly priced device, which is light, small, and even can be portable later on.

The Tool Kit

If someone is interested in repeating the simplest setup, a household microwave oven will do, provided the beam entrance is at the side, not on the top. The setup in Figure 2c is the best. One may use a thin, soft graphite rod from a mechanical pencil instead of a glowing wooden stick.

When using an acoustic cavity resonator, one may use a small amount of carbon dust packed in a small ball, wrapped in thin cigarette paper. The amount is less than a quarter of a gram, but be very careful. Its optimum depends on the initial magnetron power, size and relative position of the acoustic and metal (EM) cavity resonator. Carbon weights increase by 10 mg steps, so careful weighing is a must. If the weight of the starting carbon dust charge is too small, it will just make some sparks and fizzle out. If the weight is too much, it will just release some smoke, and it will be over.

To find out the maximum electric field in the EM (metal) cavity resonator, one may map the internal volume by placing heat sensitive, slightly wet fax paper into the cavity at different heights. There are more sensitive methods by applying cobalt chloride.[13]

You should decide at the beginning which path of technology is suitable for yourself. If you have access to a good glass blower to make quartz spheres with 0.5 mm accuracy, then atmospheric (or greater) pressures can be used. If not, and only Pyrex glass is available, then lower pressures (down to 1 - 2 Torr) are the way out, using a rotary vacuum pump. Then lower frequencies can be used, but at high voltage (10 - 20 kV). Inductively or capacitively driven tubular or spherical acoustic resonators can also be used. Resonant, lumped parameter power sources at about 14 MHz are available.

The necessary tools are professional microphones, acoustic spectrum analyzers, GM tubes, mass spectrometers, etc. However, skill in experimentation and dedication is a must.

The physics of the five essential physical phenomena are quite different though. The essential fundamentals are dusty (crystal) plasma, plasma-transversal and longitudinal wave interactions, carbon clusters (nanotechnology), surface plasmon polaritons (quasi-particles) and finally the wild and wide world of LENR or CANR. There are good books and even review papers on plasma physics and all the above areas which would help to give a more or less solid background, though none of them can be directly applied.

Some Test Results

Instead of listing the details of further hurdles, let us describe some test results.

There are only a handful of free parameters, like input power, geometry of the metal and quartz cavity resonators and their relative positions, plasma input mass flux and chemical composition. Their mutual effect is mostly unknown and even worse, counter-intuitive. This type of plasma is chaotic, but not random and unpredictable at best, wicked at worst.

Usually, if the parameters are not kept within a narrow range, the plasma sputters and vanishes. Then the transverse waves are reflected to the magnetron, and lacking a properly matched load the electronic system fails.

On the other side of the spectrum of annoying phenomena, the plasma simply jumps out of the acoustic resonator, oscillates in a corner or at the ceiling of the EM cavity resonator and is useless again. This is not our obedient servant, but a nerve cracking prankster. (So much about the real face of the phenomenon.)

The range of geometrical and other initial parameters that can be used is intermittent. That is, the useful phenomena appear only as *small islands of the parameters* on the vast ocean of possible setups. One may create a DC electric motor

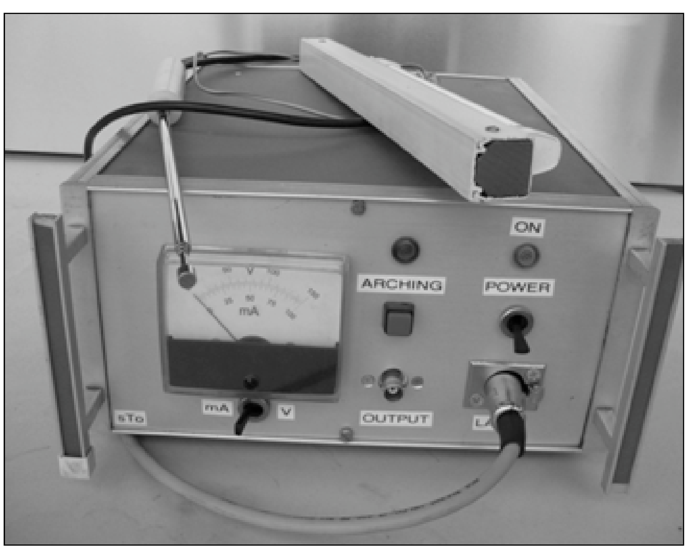

Photo 4. Tesla-wave receivers—rod and plasma antenna.

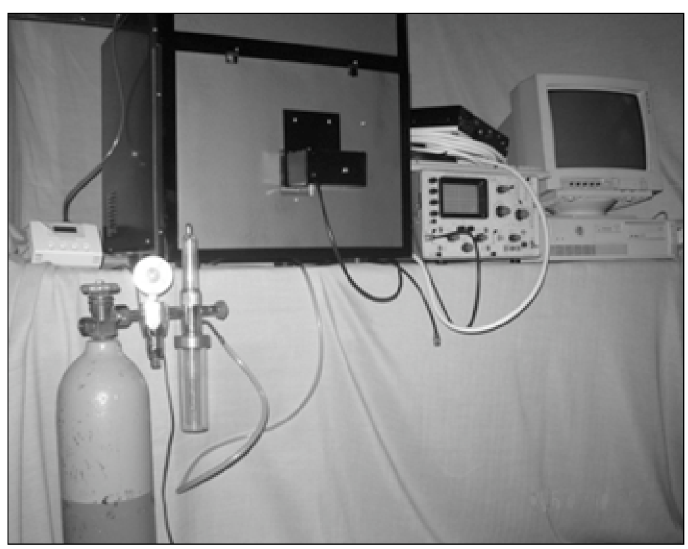

Photo 5. An early version of CO_2 thermolyzer.

of any diameter from a few millimeters up to several meters. The same is true with internal combustion engines, or spring-driven clocks, etc. But resonant dusty plasma, being strongly non-linear and self-organizing, obeys different rules. As the driving frequency of magnetrons is not a free parameter (about 2.4 GHz), given a quartz sphere of the diameter of about 5 - 8 cm, only the diameters and rim lengths of the tuning orifices provide some freedom. The safest range for a 60 mm diameter acoustic cavity resonator is a 5-mm diameter upper orifice with a rim length of 2 - 3 mm and a lower orifice of the diameter of 15 - 20 mm, and a rim length of 2 mm. The "sphericity" of the resonator should not vary more than 1 mm, otherwise the resonant peaks of the sound (quality factor) noticeably decrease. (Pyrex glass can be tried, but it will melt in a minute.)

Lower pressures provide a much wider range of possible parameters, but their power density is lower.

First Observations

Once the plasma is ignited and properly tuned, it hums, trapped in the acoustic cavity resonator. If nothing is changed, it will stay there for months. Our longest continuous test period was six weeks. It was terminated in order to examine the wear and tear of the quartz acoustic resonator. (Its inner surface became opaque, and slightly scaled, flaky, otherwise all right.)

The first question to arise is, "Why does the carbon or carbosilicate dust remain there after weeks of operation?" One would expect the termination of the phenomenon due to the slow diffusion of the initial dust out of the quartz sphere. Even a slight ventilation admitting fresh air lets the process continue, indicating a sort of *self-reproduction of the dust*. A massive flux of CO_2 will not extinguish the plasma either, indicating self-replication of the fine dust.

There is another test to prove the importance of the nanodust. When the magnetron is switched off and switched on immediately, the plasma vanishes and reappears at the same input power. For an ordinary high-pressure glow or arc discharge, a higher initial voltage (and power) is necessary for the ignition or re-ignition of the discharge. Moreover, there is a significant difference in power consumption, when the dusty resonant plasma is compared to the "pure" plasma, without an acoustic resonator, but with a rectangular transversal resonator. D.J. Sullivan *et al.*[14] has burned methane in a microwave rectangular $TE_{1,0,n}$-type resonator, while it had a laminar flame. The plasma absorbed only 22 W of the 1200 - 3400 W input EM power, increasing slightly the speed of the flame (combustion). The volume of their plasma was only a few cubic centimeters (17 mm diameter, 4 mm thickness).

In our case, an approximately 500 cm^3 (10 cm diameter) non-combustible (CO_2) plasma required an input power of about 1200 W to maintain it, yet it smashed most of the chemical bonds of CO_2. Test results are shown in Table 1.

When the magnetron-wave guide-EM cavity-acoustic cavity chain was optimized, 1 kWh of work input split 2.9 kg of CO_2 into fine C dust and O_2 with ~95% efficiency. This was the highest possible CO_2 mass flux, with a 10 cm diameter quartz sphere resonator, the largest the glass blower has ever made after several unsuccessful trials. (About 25 kWh input energy is required to decompose 2.9 kg of CO_2.)

Transmutation of medical-quality titanium is shown in Table 2, after a 6 min treatment. The data is taken from the surface sample. (Two surface samples were taken, yielding similar results.) Electron beam microanalysis was used to analyze the composition of a clean quartz sphere.

In general, the results have not always been repeatable, as there were always some differences in the geometry of the quartz acoustic resonators. Nevertheless, transmutations have always been observed after two to three minutes of treatment of the solid sample, with the exception of Ni and Fe.

As a last example, the test results of the plasma treatment of "red sludge" are shown in Table 3. This sludge is a byproduct of aluminum production, rich in minerals and metals. Most of it is iron and silica, but there are a number of rare-earth metals in it, too. The sample was a 5 g lump of slightly wet sludge. It was exposed to the plasma for 3 minutes at the bottom of the acoustic resonator, in air, at atmos-

Table 1. Raw data of CO_2 thermal-nuclear dissociation experiments. First column: 5 l/min CO_2 at 1 bar, inlet temperature about -10ºC. Second column: 10 l/min. The reaction products are cooled rapidly to ambient temperature after leaving the acoustic resonator.

User Fuel		User Fuel	
O_2 %	20.6	O_2 %	20.4
CO PPM	55	CO PPM	32
Prs mBar	0.57	Prs mBar	0.59
EFF	FAULT	EFF	FAULT
XAIR	O_2 > 20%	XAIR	O_2 > 20%
CO_2 %	0.3	CO_2 %	0.4
CO/CO_2 R	0.0183	CO/CO_2 R	0.0080
PI	1.83	PI	0.80
NO PPM	199	NO PPM	69
NO_2 PPM	8	NO_2 PPM	2
NO_x PPM	207	NO_x PPM	71
SO_2 PPM	0	SO_2 PPM	1
CxHy PPM	0	CxHy PPM	2

Table 2. Transmutation of medical Ti-Al alloy after a 6 min treatment.

Ti_1a

Spectrum: Ti_1

Element	AN	Series	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]
Aluminium	13	K-series	5.45	5.63	9.67	0.3
Silicon	14	K-series	0.06	0.06	0.10	0.1
Titanium	22	K-series	86.69	89.56	86.66	2.5
Chromium	24	K-series	0.63	0.65	0.58	0.3
Iron	26	K-series	0.29	0.30	0.25	0.2
Copper	29	K-series	2.40	2.48	1.81	0.7
Zinc	30	K-series	1.27	1.32	0.93	0.7
		Total:	96.8 %			

TiP_3

Spectrum: TiP_3

Element	AN	Series	unn. C [wt.-%]	norm. C [wt.-%]	Atom. C [at.-%]	Error [%]
Carbon	6	K-series	8.75	9.75	20.57	1.6
Magnesium	12	K-series	0.31	0.35	0.37	0.2
Aluminium	13	K-series	6.12	6.82	6.40	0.3
Silicon	14	K-series	0.06	0.06	0.06	0.1
Potassium	19	K-series	6.91	7.70	4.99	0.3
Calcium	20	K-series	0.19	0.21	0.14	0.1
Titanium	22	K-series	38.64	43.04	22.78	1.1
Chromium	24	K-series	0.45	0.50	0.24	0.3
Iron	26	K-series	0.37	0.41	0.19	0.2
Nickel	28	K-series	2.34	2.60	1.12	0.4
Copper	29	K-series	1.58	1.76	0.70	0.8
Oxygen	8	K-series	24.05	26.79	42.44	4.8
		Total:	89.8 %			

pheric pressure. After the treatment the melted, oxidized remnants were given to an accredited company to be examined by a quadrupole mass spectrometer. Column 4 of Table 3 shows the new composition after treatment. The sludge underwent a significant change; the ratio and the difference before and after the treatment is shown as well.

Under ordinary circumstances the volatile materials such as mercury should disappear, and other materials with high boiling points should be enriched, but not in this case. Here lithium was enriched by 20% (melting point 277°C). The ratio of magnesium tripled (melting point 660°C), as did the phosphorus content (melting point 44°C); the potassium content increased 17 fold. The highest yield was copper. (Its melting point is about 1000°C.) It was enriched 430 fold. Gallium was enriched by 50%, but its melting point is 30°C. Palladium was enriched 13 fold. (Its melting point is 400°C.)

Certainly the comparison has to be taken with a grain of salt, as gases were not analyzed at all, and volatile materials were allowed to evaporate and escape from the system. The data have been plotted along with the data of Miley *et al.* (on page 92), and Mizuno *et al.* (same page) from the excellent book by Edmund Storms.[9] The atomic numbers are plotted on the vertical scale, which is a logarithmic one. Storms used the production rate ($atoms/cm^3 \cdot sec$) for light water electrolysis. Mizuno used heavy water (D_2O) in plasma electrolysis, and used the total change of $atoms/cm^3$, also in logarithmic scale.

George Miley noted that there were more productive yield rates in transmutation in four mass ranges,[15] notably: A = 20-30, 50-80, 110-130, 190-210. It is true, however, that there is a good apparent increase in the Li and Be content as well. These light elements are supposed to have been created in the "Big Bang," but there is no nucleosynthesis ongoing either in supernova or in the womb of stars. There are some possible processes for the nucleosynthesis of light elements, but it would be better to carry out this test by improved methods, condensing and analyzing the volatile materials as well.

All our above results hinged on the assumption that the test results are stable "ordinary" materials, not polyneutrons, whose nucleons are ultra rich in neutrons, observed by John Fisher.[16] Electron beam microanalysis or liquid chromatography should have been done, but we could not afford them.

This method opens new doors to "synthetize" nucleons by an inexpensive technology. Therefore nuclear models developed by W.L. Stubbs, A.G. Gulko or L. Sindely will become of practical importance.

Warning

If anybody is interested in repeating these tests, please note: sub-microscopic, nano-size carbon particles are more dangerous than "regular" soot grains. Therefore ventilated premises must be used. Infrasound may cause nausea after long exposure. Tesla waves have hitherto unknown hazards,

Table 3. Red sludge composition.

red sludge			before	after	before/after	
	element	mass	b [mg/kg]	d [mg/kg]	ratio	difference
3 Li	lithium	7	28	33.7	1.20	5.7
4 Be	beryllium	9	4.13	5.72	1.38	1.59
5 B	boron	11	179	57.4	0.32	-121.6
11 Na	sodium	23	27600	27420	0.99	-180
12 Mg	magnesium	24	1400	8230	5.88	6830
13 Al	aluminum	27	36840	116800	3.17	79960
15 P	phosphorus	31	396	1320	3.33	924
16 S	sulfer	32	2990	4060	1.36	1070
19 K	potassium	39	275	4800	17.45	4525
20 Ca	calcium	40	30820	34570	1.12	3750
22 Ti	titanium	48	18420	26090	1.42	7670
23 V	vanadium	51	555	541	0.97	-14
24 Cr	chromium	52	525	501	0.95	-24
25 Mn	manganese	55	1505	1500	1.00	-5
26 Fe	iron	56	143290	136100	0.95	-7190
27 Co	cobalt	59	30.7	33.9	1.10	3.2
28 Ni	nickel	59	215	212	0.99	-3
29 Cu	copper	69	45.5	19920	437.80	19874.5
30 Zn	zinc	65	96.9	103	1.06	6.1
31 Ga	gallium	70	16	24.1	1.51	8.1
32 Ge	germanium	72	8.87	13.1	1.48	4.23
33 As	arsenic	75	93.3	56.2	0.60	-37.1
34 Se	selenium	79	0.18	0.01	0.06	-0.17
35 Br	bromine	35	3.58	9.34	2.61	5.76
37 Rb	rubidium	85	2.24	8.8	3.93	6.56
38 Sr	strontium	88	216	155	0.72	-61
40 Zr	zirkónium	91	209	238	1.14	29
41 Nb	niobium	93	7.07	7.81	1.10	0.74
42 Mo	molibden	96	12.6	8.2	0.65	-4.4
46 Pd	palladium	106	0.16	2.1	13.13	1.94
47 Ag	silver	107.8	0.11	2.53	23.00	2.42
48 Cd	cadmium	48	2.55	3.5	1.37	0.95
50 Sn	tin	119	21.6	267	12.36	245.4
51 Sb	antimony	122	20.2	6.84	0.34	-13.36
52 Te	tellurium	128	1	0.32	0.32	-0.68
53 I	iodine	127	4.78	0.19	0.04	-4.59
55 Cs	cesium	133	0.75	0.8	1.07	0.05
56 Ba	barium	137	47.8	49.2	1.03	1.4
57 La	lanthanum	139	88	47.1	0.54	-40.9
58 Ce	cérium	140	207	121	0.58	-86
59 Pr	praseodymium	141	19.1	10.5	0.55	-8.6
60 Nd	neodimium	144	72	38.1	0.53	-33.9
62 Sm	samarium	150	14.5	7.89	0.54	-6.61
63 Eu	europium	152	2.96	1.62	0.55	-1.34
64 Gd	gadolinium	157	13.4	6.7	0.50	-6.7
65 Tb	terbium	159	1.91	0.99	0.52	-0.92
66 Dy	disprosium	162	10.8	5.83	0.54	-4.97
67 Ho	holmium	165	2.2	1.24	0.56	-0.96
68 Er	erbium	167	6.64	3.86	0.58	-2.78
69 Tm	thulium	169	0.95	0.56	0.59	-0.39
70 Yb	ytterbium	173	7.13	4.23	0.59	-2.9
72 Hf	hafnium	178	9.78	4.03	0.41	-5.75
73 Ta	tantalum	181	0.07	0.02	0.29	-0.05
74 W	tungsten	184	6.15	77.9	12.67	71.75
77 Ir	iridium	192	0.01	0.01	1.00	0
78 Pt	platinum	195	0.01	0.01	1.00	0
80 Hg	mercury	200	1.82	0.12	0.07	-1.7
81 Tl	thallium	209	0.33	0.03	0.09	-0.3
82 Pb	lead	207	138	16	0.12	-122
83 Bi	bismuth	209	3.11	0.29	0.09	-2.82
90 Th	thorium	232	63.6	23.6	0.37	-40
92 U	uranium	238	22.5	3.31	0.15	-19.19

apart from their beneficial virus-killing effect. (We have developed our test device and calibration device in order to measure and shield ourselves from these waves.)

Historical Roots

It is the cautious opinion of the author that Nikola Tesla might have stumbled onto this phenomenon as early as 1891, while working on his spherical and cylindrical "carbon button" lamps (U.S. patent 454,622). Later in his "London lecture" he elaborated the test results of high frequency gas discharges with carbon, carborundum (carbosilicate) electrodes working at the parameters of about 50 kHz, and 20 kV.

He kept on returning to this subject, and he boasted later in his life that his most important result was not AC, not his version of the radio, but a tube of high voltage producing artificial radioactivity, and radiation power. There is an urban legend about his silent electricity-driven "hacked" Pierce Arrow car. It is unthinkable for an average inventor in the 1920s to have discovered and perfected controlled nuclear fusion, and to have developed it into a usable device. But he was not just another inventor, a backyard tinkerer. In a hard to find book,[17] there are photographs of a hundred odd tubes for his early radio tests. Some of them are the cospherical carbon coated tubes that could have shown the features of these phenomena after some ion bombardment (sputtering). More has to be learned about the phenomena in general, but he was well ahead of his (and our) time in many respects.

Dust Fusion in Nature?

One may presume that this phenomena may take place in the cold, dusty interstellar oscillating plasma (rich in graphite), creating some energy (dark energy?). Widom and Larsen are of the opinion that this process might take place in the solar corona, explaining its much higher temperature than that of the surface.

All in all, oscillating dusty plasma offers a chance for a more reliable, useful, renewable energy production method in our lifetime: "From dust to dust."

Further Steps

Four further rather counterintuitive, but useful technical steps need to be taken to improve further the performance of the device. Apart from the high temperature solution there is another large and useful area—using low-temperature (diluted plasma). Patent applications have been filed for both areas. As these areas are vast, and much needs to be done, we are looking for partners in experiments, management and investment.

References

1. Nagel, D. 2008. "The Intersection of LENR with Nanometer Scale Science, Technology and Engineering," *Infinite Energy*, 14, 79, 12-20.

2. There is nothing in the vast literature about plasmas that fits exactly our need, but there are dozens of good books on introductory (regular) plasma physics. My favorite is a short, enlightening book: Arzimovich, L.A. 1965. *Elementary Plasma Physics*, Blaisdell Publications. Contact me for a list of good introductory books and papers on dusty plasmas.

3. The plasma wakefield acceleration is a very useful, indispensable auxiliary effect. There are dozens of experimental papers on the subject, but no textbook so far. Contact me for a list of references.

4. Unduly neglected works on magnetic monopoles and attraction by light upon nano and micro particles. These are also quasi-particles. The physicists are looking for them in the wrong place as elementary particles. Contact me for a list of references.

5. Plasmon polaritons are strange quasi-particles, but they have already been applied in industry. A good, short overview is: Stockman, M.I. 2011. "Nanoplasmonics: The Physics Behind the Applications," *Physics Today*, February, 39-44. The paper clearly outlines the useful parameter range of the phenomenon: particle size 2 - 20 nm; plasmon relaxation time 10 femtosecond, polarization time within 100 attosecond, local field enhancement scale between 10^4 - 10^8. For elongated particles this can be further increased. In general, there are two characteristic electric fields and frequency ranges. The very strong internal electric fields and Tesla waves due to plasma oscillations by acoustic resonance are in the kHz-GHz range. The weaker fields generated by the plasma from infrared to soft X-rays are in the order of Terahertz. Both contribute to surface and volumetric electric field amplification, but the rate of their individual contribution would be just a guesswork. In arc discharge, perhaps only the latter works—as in the Quantum Rabbit tests, or underwater arc discharges by the Graneaus. Contact me for a list of references.

6. Unfortunately we had no access to a transmission electron microscope, so we have no information on the actual size and distribution of the nano-particles responsible for the beneficial effects. However, there is a rich and rapidly growing body of knowledge on carbon nano-size dust, which is of our main concern. Most probably closed-surface carbon grains (like C_{540}), carbon tubes and irregular carbon polymers participate in the reactions. Surface and volumetric plasmon polaritons can excite closed surface and conductive carbon nano-tubes of multi wall. Fluffy, irregular, insulating grains of the range of 1 nm to even #m may take place in the reaction involving charge shielding phenomena. There is a vast and growing body of knowledge on how carbon nanoparticles are grown. This process is not the usual way of engineering, not "from top to bottom" manufacturing. On the contrary, it is a "bottom up" process. It involves 9 orders of magnitude, as the size difference between a 20 nm nanotube and a 50 cm manufacturing device is so wide. If we add that we manufacture the carbon nucleus from electrons and protons, the size gap is even wider. This difficult and complicated chain of interactive phenomena lies at the heart of the whole process. Contact me for a list of references.

7. The hydrino model of R.L. Mills has many attractive features to explain (partially) the radioactivity-free part of the dust fusion process. However it requires special catalysts, like atomic lithium, and molecular NaH, but these catalyst are usually not present. Ar and He ions may serve also as catalysts, and they are present in air. We have made tests in sealed glass cylinders, full of atmospheric and sub atmospheric argon, but not in acoustic resonators. The ignition process worked well, as usual, but the Pyrex glass melted immediately. Therefore the test was inconclusive; a more sophisticated setup would be necessary to decide if it works in atmospheric argon. Nevertheless it is quite possible that this process also takes place. The Mills process does not require plasma oscillations or extended solid-plasma surface. In a 2002 paper by R.L. Mills and P. Ray ("Vibrational Spectral Emission of Fractional-Principal-Quantum-Energy-Level Hydrogen Molecular Ion," *Int. J. Hydrogen Energy*, 27, 533-564) a microwave driven plasma is used at very low pressure. (A turbo pump is used.)

8. In principle, the electron-proton combination model of Widom and Larsen has a number of very attractive features, but the technical details are foggy, especially on exactly what a "heavy" electron is, and how to make them. Their two published patents are: 2008/0296519 and 2008/0232532. (They include their theoretical papers as well.) The technical parameters of their suggested use of room temperature metallic (palladium) substrate-electrolysis is a very poor technical environment for the implementation of their proposed theoretical model, but otherwise good. There are a number of other "neutral particle" models not discussed here. Most of them are useful. The Widom-Larsen model refers to collective electron and proton oscillations, without technical specifics on how to create them. Their patent is more of a theoretical physics paper then a guide how to make a device and how to use it. However, their line of thought is worthy of consideration, and after considerable refinement could be used to explain the radioactivity free part of the dusty plasma nuclear process.

9. Storms, E. 2007. *The Science of Low Energy Nuclear Reaction*, World Scientific. The book is an excellent and comprehensive, balanced overview of the "cold fusion" field. It is a "must" for every experimenter in this field. In the review of past experiments it is clear that most tests were carried out along the classical Pons-Fleischmann lines of heavy-water electrolysis with a Pd cathode. There is another useful two-volume book written by several prominent researchers: *Low Energy Nuclear Reactions Sourcebook*, Vol. I. and Vol. II., ed. Jan Marwan and Steven B. Krivit, American Chemical Society Series 998.

10. There are only a few papers on longitudinal (Tesla) waves: Monstein, C. and Wesley, J.P. 2002. "Observations of Scalar Longitudinal Waves," *Europhysics Letters*, 59, 4, 514-520; Meyl, K. 2003. *Scalar Waves*, Indel GmbH, www.meyl.eu; Wesley, J.P. 2002. *Scientific Physics*, Samizdat, 125-128.

11. Dust in the "official" plasma: Weynants, R.R. 2009. "ICRF Review from Erasmus to ITER," *RF Power in Plasmas*, AIP Proc. 18th Conference, eds. V. Bobkoov and J.M. Noteredaeme, Gent, Belgium, June 24-26. See p. 9: "The growing realization that the gross erosion rates for graphite due to physical and chemical sputtering would be excessive in a reactor and that tritium co-deposition by redeposition of graphite would be prohibitive, has led to a return to the old all metal concept favoring high Z material, mainly W at critical wall areas." See also: Fundamensky, W. 2010. *Power Exhaust in Fusion Plasmas*, Cambridge Univ. Press, 208 for plasma-impurity interactions. For the "stellar" excessive technical parameter requirement of ITER and Inertial Confinement Fusion see: Lindemuth, I.R. and Siemon, R.E. 2009. "The Fundamental Parameter Space of Controlled Thermonuclear Fusion," *Am. J. of Physics*, 77, 5, 407.

12. Fortunately, there are a number of books about nonlinear phenomena. Some of them concerning plasma physics and dusty plasma are quoted in Reference 2. But the fundamental physics are usually shrouded in mathematical formulae, with little insight to the essence. But there is an exception written by Russian scientists: Gaponov-Grekhov, A.V. and Rabinovich, M.I. 1988. *Nonlinearities in Action: Oscillations, Chaos, Order, Fractals*, Springer. For us synchronization is of concern. There is a good (advanced level) book on the subject: Pikovsky, A. *et al.* 2003. *Synchronization*, Cambridge Univ. Press. There are some essential concepts which are helpful understanding the dusty plasma oscillations, like: Parametric excitation, mode coupling, self excited oscillations, self organized structures, spatio-temporal competition, synchronization of noisy systems, Arnold instability tongues, entrainment of several oscillations by a common drive, mode locking, Devil's staircase, etc. Self-organizing non-linear dusty plasma is amazingly stable. Its behavior is very strange, even counter-intuitive to our linear-based way of thinking.

13. There are hundreds of books on microwaves, some for plasmas, quoted in Reference 2. But a good introduction to microwave ovens is: Vollmer, M. 2004. "Physics of the Microwave Oven," *Physics Education*, 39, 1, 74, January. To map the maximum field in a metal cavity resonator a good introduction is: Kamoletal, S. 2010. "3D Standing Waves in a Microwave Oven," *Am. J. of Phys.*, 78, 5, May, 492.

14. Sullivan, D.J. *et al.* 2004. "Microwave Techniques for the Combustion Enhancements," 40th ASME Joint Conference: AIAAA, 3713.

15. Miley, G.H. and Shrestha, P.J. 2008. "Transmutation Reactions and Associated Low-Energy Nuclear Reactions Effects in Solids," *Low Energy Nuclear Reaction Sourcebook*, Vol. I, 173-218.

16. Macy, M. 2010. "The Fisher-Oriani Collaboration," *Infinite Energy*, 16, 4, 10-18.

16. Anderson, L., ed. 2002. *Nikola Tesla on His Work with Alternating Currents and Their Application to Wireless Telegraphy, Telephony and Transmission of Power: An Extended Interview*, Tesla Presents Series, Part 1, Twenty-First Century Books.

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George Egely graduated from the Technical University of Budapest (1973). He worked at the Nuclear Energy Research Lab of the Hungarian Academy of Science from 1974 to 1990. He was a guest researcher at CISE (Italy) in 1977 for three months, and at Brookhaven National Lab (U.S.) in 1981-82 for 16 months. He received his Ph.D. in 1982, on the subject of nuclear accidents of pressurized water reactors (PWR). Egely has compiled a large collection of ball lightning observations by eyewitnesses, and published a couple of semi-popular books on this subject. He is the author of three textbooks on the physics of "lost or forgotten" effects and inventions, and of several semi-popular books on the same subjects (in Hungarian). Since 1990 he has been a team leader in several small projects in alternative technologies. Some videos of these tests are posted online: www.greentechinfo.eu

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