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A Hybrid Craft using an Inertial Mass Modification Device

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It is possible to envision a hybrid aerospace-undersea craft (HAUC), which due to the physical mechanisms enabled with an inertial mass reduction device, can function as a submersible craft capable of extreme underwater speeds (lack of water-skin friction due to electromagnetic field-induced water molecules repulsion) and enhanced stealth capabilities (non-linear scattering of radio frequency and sonar signals). This hybrid craft would move with ease through the air, space, water mediums, by being enclosed in a bubble (shield), generated due to the coupled effects of electromagnetic field induced air/water particles repulsion and vacuum energy polarization. Moreover, it may be possible to reduce the inertial mass of a system/object in motion, by applied high energy electromagnetic fields, achieved by a novel coupling of accelerated high frequency vibration with accelerated spin of electrically charged matter in close proximity to the system/object in question. This original method of accelerated spin/accelerated vibration of charged matter would be executed under rapid acceleration transients for maximum effect. The resultant high energy flux (on the order of 10^{33} Watts/m^2) when concentrated in a small area around the contour of the object (craft) can generate energy densities of 10^{25} Joules/m^3, commensurate with Schwinger electric field values for vacuum polarization. As a result, extreme craft speeds can be achieved, thus enabling a novel method of advanced propulsion.

I. Introduction

The original concept described herein, gives rise to the design of an inertial mass reduction device (IMRD) and materializes into the hybrid aerospace-undersea craft (HAUC). When put in practice, this system can lead to the design of energy generation machinery with power output levels much higher than those currently achievable. The utilization of such high power sources for space power and propulsion generation, as it pertains to reduction in a hybrid craft's inertial mass as a direct result of local vacuum polarization, is an important application of the described theoretical concept.

This concept's governing physics teaches that it may be possible to reduce the inertial mass of a system/object in motion, by applied high energy electromagnetic (EM) fields, achieved by coupling of accelerated high frequency vibration with accelerated spin of electrically charged matter in close proximity to the system/object in question. This original method of accelerated spin and/or accelerated vibration of electrically charged matter would be executed under rapid acceleration transients for maximum effect.

There are four known fundamental forces which control matter and therefore control energy, namely the strong and weak nuclear forces, the electromagnetic force and the gravitational force. In this hierarchy of forces, the electromagnetic force is perfectly positioned to be able to manipulate the other three. A stationary electric charge gives rise to an electric (electrostatic) field, while a moving charge generates both an electric and a magnetic field (hence the electromagnetic field); additionally an accelerating charge induces electromagnetic radiation in the form of transverse waves, namely light. Mathematically as well as physically, electromagnetic field energy flux can be represented as the product of electric field strength and magnetic field strength. Electromagnetic fields act as carriers for both energy and momentum, thus interacting with physical entities at the most fundamental level.

Artificially generated, high energy, electromagnetic fields interact strongly with the vacuum energy state, an aggregate/collective state comprised of the superposition of all quantum fields' fluctuations permeating the spacetime continuum [1]. According to quantum field theory, this strong interaction between the fields is based on the mechanism of transfer of vibrational energy between the fields, further inducing local fluctuations in adjacent quantum fields which permeate spacetime. These fields may or may not be electromagnetic in nature [2]. Matter, energy and spacetime are emergent constructs which arise out of a fundamental framework, the foundational structure that is the vacuum, energy state.

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Everything that surrounds us, ourselves included, can be described as macroscopic collections of fluctuations, vibrations, oscillations in quantum mechanical fields. Matter is confined energy, bound within fields, frozen in a quantum of time. Therefore, under certain conditions, such as the coupling of high frequency axial spin with high frequency vibrations of electrically charged systems, the rules and special effects of quantum field behavior also apply to macroscopic physical entities [3].

Consider that we are immersed in an ocean of energy, the vacuum energy state, yet ordinarily we seem not to interact with it. This is because under normal circumstances (at or near equilibrium), the vacuum state is homogeneous, isotropic, Lorentz invariant, in other words it is symmetric. Break this symmetry (far-from-equilibrium), and strong interactions with the vacuum energy state become possible, thus affecting the manner in which the collective fields exchange energy with one another.

If we perform a "gedankenexperiment" we observe that the coupling of high frequency spin with high frequency vibration, especially for rapidly accelerated spin/vibration of an electrically charged system (object) puts every point on the boundary of the object in a state of coherent superposition, thereby inducing a macroscopic quantum phenomenon [4].

Moreover, as observed from the Casimir effect, the boundary conditions of a physical system affect the local vacuum energy state (VES) of that system (comprised of zero point EM energy (QED) among other types of field energies (QCD, Higgs, etc.)) thereby affecting the system's physical properties [1]. Thus by manipulating/modifying the boundary conditions of a physical system with respect to its local VES (local quantum vacuum), we can alter the system's physical properties.

Investigation of the quantum vacuum as a source of propulsion estimated the very short scales of time and distance (and hence the high energies) over which the quantum vacuum must be interacted with for extracting enough propulsive energy for relativistic interstellar flight. Based on this investigation, it was suggested that a system's inertia may be a consequence of quantum vacuum electromagnetic behaviour, therefore by polarizing the vacuum in the proximity of the system, inertial mass reduction may be achieved [5-9].

Polarization of the local vacuum energy state is analogous to manipulation/modification of the local spacetime energy density, so as to reduce the resistance to motion of a propagating craft. As a result, extreme craft speeds can be achieved, thus enabling a novel method of advanced propulsion.

II. High Energy Electromagnetic Flux Generation

As originally observed in reference 4, for conditions of accelerated vibration or accelerated spin of an electrically charged object/system, we can write for the maximum EM energy flux (time rate of change of EM energy transfer per unit surface area):

$$S_{max} = f_G (\sigma^2 / \varepsilon_0) [(R_v \nu^2) t_{op}] \quad (1)$$

, where f_G is the charged system geometric shape factor (equal to 1 for a disc configuration), σ is the surface charge density, ε_0 is the electrical permittivity of free space, R_v is the vibration (harmonic oscillation) amplitude, ν is the angular frequency of vibration in Hertz, and similarly in the case of axial spin R_v is the effective system radius, while ν represents the angular frequency of rotation, and t_{op} is the operational time for which the electrically charged system is operated at maximum acceleration ($R_v \nu^2$). This closed form formulation is the result of the synthesis of classical electromagnetic field theory with the physics of simple harmonic motion.

Furthermore, for the case of rapid time rates of change of accelerated vibration / spin (rapid acceleration transients) of the charged system, given that the time differential of acceleration is non-zero, we obtain:

$$S_{max} = f_G (\sigma^2 / \varepsilon_0) [(R_v \nu^3) t^2_{op}] \quad (2)$$

This is a thought provoking formulation because it shows that even with moderate vibrational / spin frequencies in a rapidly accelerating mode, the EM energy flux is greatly amplified.

Thus if the product of all the controllable parameters in equation 2 (other than the angular frequency of vibration) was of unit order, we can achieve energy flux values on the order of 10^{33} W/m^2 (endemic of the polarized vacuum energy state) with low end microwave frequencies on the order of 10^7 Hz , inducing vibrations of a resonant

cavity wall of equal or higher frequencies, depending on cavity material. This in itself may qualify as an interesting observation, showing the extensive capabilities of a high energy / high frequency electromagnetic field generator.

Furthermore if we consider adding to the equation representing simple harmonic motion an "energy/momentum-pumping" (negative damping) term (bv), endemic of system acceleration, where b is a constant and v is (dx/dt), namely the speed of a vibrating mass (m), something interesting occurs, in that it can be shown that the maximum of the total energy (E_T) of the vibrating system can be written as:

$$E_T \approx m R_v^2 \Omega^2 [\exp (2 \Omega t)] \quad (3)$$

, where Ω is the angular frequency of vibration, under the condition [$\Omega = (b/2m) >> \Omega_0$ (natural frequency of vibration)]. Since the EM energy flux is directly proportional to E_T, we observe that there will be exponential growth in energy flux with accelerating vibration, especially under the condition of rapid acceleration transients.

Considering a classical Newtonian second law expression using the Lorentz (EM) force, we can relate the vibrating mass (m) with its vibrating charge (Q), in that m becomes directly proportional to the square of the ratio (Q / Ω). Coupling this relation with equation 3 yields:

$$S_{max} \approx (Q^2 / \varepsilon_0) (R_v^2 / R_s^5) \Omega [\exp (2 \Omega t)] \quad (4)$$

Equation 4 represents the maximum EM flux that can be achieved by accelerated vibration under the aforementioned condition, and applies to a spherical geometry (radius R_s) for a vibrating mass (m) of corresponding charge (Q).

The resultant high energy EM flux, on the order of 10^{33} Watts/m^2, and possibly much higher, when concentrated in a small area around the contour of the object (craft) can generate energy densities of 10^{25} Joules/m^3, commensurate with Schwinger electric field values for vacuum polarization [9,10]. This physical condition is representative of the QED vacuum breakdown and is indicative of possible inertia control by altering the local vacuum energy density [1].

If we consider cosmic space as a superfluid medium [11], we may be able to say that the IMRD device has the capability of inducing a local phase transition from a turbulent regime to a laminar regime, thus allowing for "smooth sailing" of a hybrid craft (HAUC) through the specially conditioned vacuum of Space. This is a vacuum that has undergone macroscopic quantum coherence, locally, around the craft. As a result, the craft experiences "suction" into the conditioned vacuum.

It is a well-known facet of quantum field theory that everything can be described in quantum mechanical terms. The complex interactions between a physical system and its surroundings (environment), disrupt the quantum mechanical nature of a system and render it classical under ordinary observation. This process is known as decoherence [3].

However, it is argued that we can retard (delay) decoherence (and possibly even suppress it – namely decouple a physical system from the environment) by accelerated spin and/or accelerated vibration of electrically charged matter under rapid acceleration transients.

This may be the very condition to achieve a state of macroscopic quantum coherence, the idea being that we never let the system achieve thermodynamic equilibrium, by constantly delaying the onset of relaxation to equilibrium (hence the production of maximal entropy is delayed). The system may "violently" react by generating "anomalous" emergent phenomena, such as, but not limited to, inertial mass reduction.

Enter the Prigogine effect, as described in reference 4, on page 316.

The Prigogine effect teaches us that depending on three conditions, a chaotic system, namely the 'soup' of fluctuations that make up the vacuum energy state, can self-organize into an orderly state, equivalent to the state of macroscopic quantum coherence.

These conditions are the existence of a highly non-linear medium (the cosmic superfluid), an abrupt departure far-from-thermodynamic equilibrium (the accelerated spin/vibration of charged matter) and last but not least an energy flux (the generated EM energy flux) to maintain the process of self-organization (order from chaos).

All three conditions for the Prigogine effect are met in our application, thus it can be argued that a possible theoretical path toward inertial mass reduction induced by macroscopic quantum coherence is herein established.

III. Possible Mathematical Formalism of Inertial Mass Reduction

Consider that it may be possible to reduce the inertial mass and hence the gravitational mass (based on the Equivalence Principle), of a system/object in motion, by an abrupt perturbation of the non-linear background of local Spacetime (the local Vacuum energy state). This abrupt perturbation is equivalent to an accelerated departure far from thermodynamic equilibrium, analogous with Symmetry-breaking induced by abrupt changes of state (structure).

Moreover, it is possible to argue that gravitational (inertial) mass reduction is feasible by high frequency accelerated axial rotation (spin) and/or accelerated high frequency vibration of possibly charged objects, within the context of non-equilibrium thermodynamics.

In a published Physical Review Letter [12], Hayasaka and Takeuchi report the anomalous weight reduction of gyroscopes for right rotations only. At the time, the authors could not elucidate the physics behind these anomalous results. Several null result experiments followed [13-15], which declared the Hayasaka et al. results null and void, or at least questionable.

As described in Ref. 13, there were several differences between refs. 14 and 15 with respect to ref. 12, chief among these being the gyroscopes were spun in closed but not evacuated containers. Furthermore, the rotors were air driven rather than electrically driven, which may result in experimental inaccuracies. The main experimental set-up difference between ref. 12 and ref. 13 is that the pressure range within the vacuum container in the Hayasaka et al. experiment was reported as 1.3×10^{-2} Pa to 1.3 Pa while the Nitschke et al. experiment reported a pressure range of 1 – 3 Pa in the evacuated container. Moreover, refs. 13 - 15 experiments did not use the same gyroscope assemblies as used in ref. 12, nor the same experimental set-up as shown in figure 1 of the Hayasaka et al. work. It can be argued that exact replication of the experimental set-up and gyro-rotational acceleration procedure used in the anomalous weight reduction experiment was not achieved by any of the null result experiments. Two more relatively recent experimental attempts at nullifying the Hayasaka et al. experiment have been made [16, 17]. These attempts also do not correctly reproduce it (both experimental set-up and procedure), namely ref.16 performs the experiment with free-falling rotating gyroscopes, while ref.17 performs the experiment in a sealed environment only, without an evacuated test chamber.

It is important to note that in the Hayasaka et al. experiment, the gyro-rotor was electrically spun, which means there could have been an electrical charge on the rotor, however small, yet strong enough to possibly repel the air molecules close enough to the rotor (as shown in their figure 1) thus generating the negative pressure effect which possibly produced the anomalies observed.

In other words, the existence of a charge on the rotor, could have generated an EM energy flux strong enough to produce an ultrahigh vacuum condition in close proximity to the rotor, endemic of the quantum vacuum state (air particles' repulsion coupled with possible Vacuum polarization).

This can be possible when considering the idea that controlled motion (either by accelerated vibration and/or accelerated spin) of charged matter under rapid acceleration transients can induce macroscopic quantum coherence, locally.

Closer attention to the non-zero intercept of the Hayasaka et al. expression relating the gyro's weight diminution with respect to its mass, its angular rotational frequency and its effective rotor radius, yields the possibility of a local quantum Vacuum effect, namely a negative pressure (repulsive gravity) condition being present. This is due to the non-zero intercept being of the same order of magnitude with the Fokker-Planck electron-proton thermal equilibration rate, given an approximate Hydrogen atom number density of 40 atoms/m^3, commensurate with the local Vacuum state.

Consider the Hayasaka et al. expression for gyro-weight reduction, written in SI units as:

$$\Delta W_R(\omega) = -2 \times 10^{-10} M r_{eq} \omega \quad (\text{kg m s}^{-2}) \tag{5}$$

, where ΔW_R is the reduction in weight, M is the mass of the rotor (in kg), ω is the angular frequency of rotation (in rad/s), and r_{eq} is the equivalent gyro-radius (in m).

From this relationship we see that the units of the non-zero intercept (2×10^{-10}) are (1/s).

This non-zero intercept is endemic of the physics of gyro-rotational acceleration, as follows.

It is possible to argue that as the gyro-rotor accelerates in its rotation, there is an abrupt departure far from thermodynamic equilibrium (within the evacuated container), given the high limit of angular rotational frequency of 1.3×10^4 rpm.

Recall that the Hayasaka et al experiments were performed at room temperature (approximately 300 ^{0}K). Hypothetically speaking, we can think of the air particles within the evacuated container as giving rise to a non-thermal plasma (any plasma which is not in thermodynamic equilibrium because the velocity distribution of one of the species does not follow a Maxwell–Boltzmann distribution), formed when the matter inside the evacuated container is driven far from thermal equilibrium by the abrupt gyro-rotor acceleration. The system will now try to reach thermal equilibrium and this will be dependent on the electron-proton thermal equilibration rate.

Recall from plasma physics [18], that Coulomb collisions between the plasma's electrons and protons will in time (once the gyro-acceleration has ceased) force the particles to randomly exchange energy, and thus drive them into thermal equilibrium. Thus, in time the particles will equilibrate at the room temperature at which the experiment was conducted (assuming a non-Maxwellian velocity distribution).

Using the Fokker-Planck formulation for the electron-proton thermal equilibration rate (f_{ep}) with units of (1/s), we can write:

$$f_{ep} = (2n\sigma_T c \ln\Lambda / \pi^{1/2}) (m_e / m_p) (k_B T_e / m_e c^2)^{-3/2} = 4 \times 10^{-8} (n / 1\ m^{-3}) (T_e / 1^0 K)^{-3/2} (\ln\Lambda / 10)(s^{-1}) \quad (6)$$

, where n is the Hydrogen atom number density, σ_T is the Thompson cross-section (which equals 6.65 x $10^{-29} m^2$), $\ln\Lambda$ is the Coulomb logarithm (we set this at 10 to counteract its effect since this is a non-thermal plasma), T_e is the temperature at which the electrons and protons will equilibrate (approximately 300 ^{0}K).

Using a (n) value of 40 atoms/m^3, which is commensurate with the density of matter in the Vacuum (approx. 7x10 $^{-29}$ g/cm^3), we obtain a thermal equilibration rate on the order of 10 $^{-10}$ (1/s).

In light of this result, we can affirm that the non-zero intercept in the Hayasaka et al. gyro-weight reduction expression has the same order of magnitude as the thermal equilibration rate, thus matching the physics described above.

Leaving aside the inconsistency between the Vacuum of General Relativity and that of relativistic quantum field theory (best expressed by the Cosmological Constant discrepancy), the Vacuum's energy density is characterized by a negative pressure, and thus a repulsive gravity, which would explain the gyro-weight reduction effect, if indeed the local Vacuum state is achieved. We define the local Vacuum state as the macroscopic aggregate /collective state comprised of the superposition of all fluctuations in the quantum fields that permeate local spacetime.

Furthermore, we can assert that since the thermal equilibration rate is a function of the inverse temperature (raised to the 3/2 power) at which thermal equilibrium is re-established, if we were to cryogenically cool the gyro-rotor (which could be made from a superconducting material) to a temperature of (10^{-3}) ^{0}K (or below) we would obtain further reduction in the gyro-weight, if the Hayasaka et al result holds valid.

As an aside, we can hypothesize that if the gyro-rotor was to vibrate uniformly (instead of rotating), and its vibration (harmonic oscillation) was to accelerate in frequency (thus inducing a state of abrupt departure from thermodynamic equilibrium), it is possible that the resulting physics would be the same as that describing the rotational acceleration, thus we may write (using a simple dimensional analysis):

$$\Delta W_R(\nu) = - f_{ep} M A_\nu \nu \quad (kg\ m\ s^{-2}) \quad (7)$$

, where f_{ep} is the thermal equilibration rate, A_ν is the vibration amplitude and ν is frequency of vibration (in 1/s).

It is true though, that the presented hypothesis on the possible equality between the Hayasaka et al. non-zero intercept and the thermal equilibration rate (which is related to the electron-proton collision frequency) does not explain why the gyro-weight reduction only occurs in the right rotation mode (since the abrupt excursion from thermodynamic equilibrium caused by the gyro-rotor's rotational acceleration should occur for left rotations as well).

Due to this inconsistency (in addition to the non-zero intercept explanation as the thermal equilibration rate), as well as the lack of exact replication of the Hayasaka et al. experiment (both set-up and procedural aspects), further investigation into the reproducibility of this experiment is in demand, which if verified/validated has important implications in the advancement of foundational physics.

In view of the described physics, it is suggested that the Hayasaka et al. experiment be executed under the following conditions: a pressure of 10^{-4} to 10^{-2} Pa in the evacuated chamber, a gyro-spin frequency range of 1.3×10^4 to 10^5 rpm, and most importantly, under high rates of change of rotational and vibrational acceleration (to ensure abrupt departure far from equilibrium). It is further suggested, that the gyro-rotor be electrically charged, with at least a unit order surface charge density. Moreover, execute the transient ramping up-down-up of the rotor charge.

The results of these proposed experiments would greatly benefit new advancements in Aerospace Propulsion (conducive to Intergalactic Spaceflight), since it would show that it is possible to reduce the inertial mass, and hence the gravitational mass, of a system/object in motion, by an abrupt perturbation of the non-linear background of local Spacetime, equivalent to an accelerated departure far from thermodynamic equilibrium, analogous with Symmetry-breaking induced by abrupt changes of state / phase transitions. As a result, extreme speeds can be achieved.

IV. Enablement of HAUC Concept

The coupling of high spin frequency with high vibration frequency in order to achieve the desired inertial (gravitational) mass reduction effect, can lead to the design of an Inertial Mass Reduction Device (IMRD), shown in figure 1 in a hybrid aerospace/underwater craft (HAUC) configuration. This device utilizes microwave-induced vibration within a resonant annular cavity. The manner and effectiveness with which the microwave energy couples with the resonant cavity inner wall is called the cavity Q-factor. This parameter can be written as the (Energy stored / Energy lost) ratio and is in the range of 10^4 to 10^9 (and beyond), depending on whether ordinary metal (Aluminum or Copper at room temperature) or cryogenically cooled superconducting material (Yttrium Barium Copper Oxide or Niobium Germanium) is used for the resonant cavity inner wall and outside mold line skin of the aerospace vehicle. One must realize that the high energy/high frequency electromagnetic field generator responsible for the inertial mass diminution effect would generate a repulsive EM energy field while in earth's atmosphere, thereby repelling air molecules in its path of ascent/flight. Consequently, once in orbital space, by local Vacuum polarization (quantum field fluctuations' modification), a repulsive gravity effect (recall the negative pressure of the polarized Vacuum condition) would permit swift movement of the hybrid craft (which comes in either a cone or lenticular triangle /delta wing configurations), beyond our Solar System. A plurality of microwave antennas (high radio frequency emitter sources) in the electromagnetic (EM) spectrum range of 300 Megahertz to 300 Gigahertz are arranged within the annular duct - resonant cavity (surrounding the crew compartment and powerplant system, which would be guarded in a Faraday-type cage, against all EM radiation effects), as portrayed in figure 2. An auxiliary propulsion unit (not shown), would provide the initial aerospace/undersea hybrid vehicle thrust and electrical power generation. Furthermore, if the annular resonant cavity duct is filled with a noble gas such as Xenon (inert), the microwave energy collision with the gas particles will induce a plasma state of matter (further augmenting the oscillatory vibrations experienced by the resonant cavity inner wall), thereby creating a highly non-linear environment (phase transitions / abrupt changes of state from gas to plasma, which induce symmetry breaking) which will intensify the Prigogine effect (order from chaos - reference 4). This will enable the coherence of quantum vacuum fluctuations in the proximity of the outside mold line skin (electrically charged) of the aerospace vehicle, in this manner assuring a high degree of vacuum polarization.

Therefore, it is possible to envision a hybrid aerospace / undersea craft (HAUC), which due to the physical mechanisms enabled with the IMRD, can function as a submersible craft capable of extreme underwater speeds (lack of water-skin friction) and enhanced stealth capabilities (non-linear scattering of RF and sonar signals). This hybrid craft would move with great ease through the air/space/water mediums, by being enclosed in a Vacuum plasma bubble/sheath, due to the coupled effects of EM field-induced air/water particles repulsion and Vacuum energy polarization.

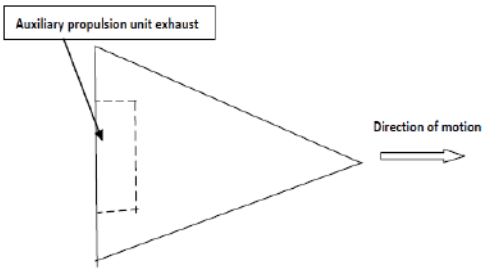

Figure 1. Hybrid Aerospace/Undersea Craft (HAUC) configuration

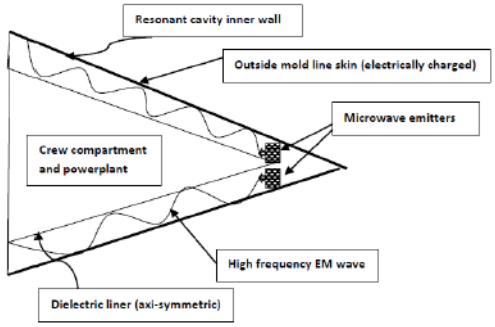

Figure 2. IMRD -Microwave Emitter configuration (Cross-sectional side view)

V. Conclusion

The original concept presented in this paper, suggests that it is possible to design a hybrid craft which by delivering vast amounts of electromagnetic energy flux in its close proximity can alter the spacetime energy density in that locality. In this manner, the craft can move at extreme speeds, due to quantum electrodynamic Vacuum breakdown effects, which result in inertial mass reduction. In parallel, controlled motion of electrically charged matter under accelerated vibration and/or accelerated spin and subjected to rapid acceleration-deceleration-acceleration transients, can be used in conjunction with nested EM fields (EM fields within EM fields) and the enablement of the Gertsenshtein effect, in order to manipulate / modify gravitational fields for propulsion, or to provide novel methods of plasma confinement and compression for nuclear fusion research.

Moreover, it is important to note that the extremely high EM energy flux magnitudes achieved with the concept at hand can be used in the design of space systems which could deflect, re-direct and/or destroy asteroids, such as Apophis (99942), on possibly dangerous trajectories close to Earth in 2029 and 2036. Such a system is the subject of US Patent Application number US 2017/0025935 A1, titled "Electromagnetic Field Generator and Method to Generate an Electromagnetic Field".

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