

The Unknown Nature of the Energies That Make the Sun Shine and the Dream of Controlled Fusion on Earth

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Abstract

The Sun makes its everyday job, heating us and maintaining the merry-go-round of the planets, simultaneously using the main energies that govern the Universe: Gravity, the strong nuclear and the weak interaction. The Sun realizes, in its operation, the Grand Unification of natural energies whose nature is seldom misunderstood and their contribution in making the Sun shine is not completely recognized. This paper re-states the close relation among natural energies, reviews the Sun data and the main fusion reactions, analyzes the attempts to reproduce the fusion process on Earth and suggests possible solutions.

Keywords

Gravitation, Weak and Strong Nuclear Interaction, Neutrino, Grand Unification Theory, Fusion Process

1. Introduction

Newton had some problems understanding why his Universal Gravitational Law worked so well in shaping and sizing the celestial bodies, the first discrepancies arising when, coupling the “attraction force” with his differential equation of motion, he encountered the three-body problem [1].

Einstein replaced the “force” with a Gravitational Field, extending to Gravity the fluid dynamic and electromagnetic field approach [2], but the complexity of mathematics has been a deterrent for its use on Earth and in astronomic computations.

Now it has been shown that Newton Law is far of being universal and a correction is needed for stars and gaseous planets [3], that it is possible to explain the

time lag of planets [4] and easily compute the motion of celestial bodies [1], trace the past and future of the universe [5] and give a name and a figure to unknown entities such as dark matter and energy [6].

These are some of the many question marks of physics and have been solved by a novel approach to the nuclear atom and to its dynamics in generating Gravity, the weak nuclear interaction and the strong nuclear bond.

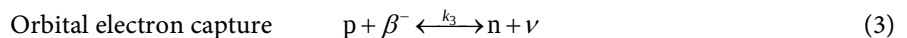
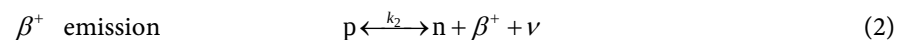
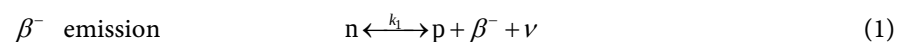
This view might help understand the operation of the Sun and make some contribution to the research underway on fusion process.

For the sake of novel readers, this new approach will be treated in detail before discussing the fusion reactions in the Sun and the problematic controlled fusion in a nuclear reactor.

2. Weak Interaction

The nuclear weak interaction is the key for the unification of Gravity and the strong nuclear attraction and is the basis of all physical phenomena, including the initial spark for lightening the Sun and the Stars.

Introduced by Enrico Fermi for β decay (1937 Nobel prize), it has been extended to all atoms radioactive and stable to represent the proton-neutron (n-p) transformations inside nuclei with beta β and neutrino ν emission.



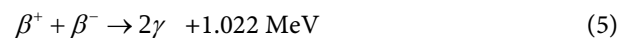
The determination of the reaction parameters k is based on the experimentally known 15 minutes half-life of neutron and the available neutron-proton distribution of 1812 stable and unstable nuclides that constitute our Universe.

From the apparent simplicity of this correlation, the following values can be obtained:

$$k_1 = 0.0009625 \quad k_2 = 4.71554\text{E}-06 \quad k_3 = 0.00105382 \quad (4)$$

The accuracy of this fit is surprisingly almost 100% such that these parameters could be accepted as universal constants, based on experimental data.

We must consider, in addition, the following annihilation reaction with an important Q energy value:



This Q energy value of 1.022 MeV will be used for nuclear bond computation.

Reaction (1) is the neutron decay: free neutrons do not exist in nature but are the most important building blocks of atoms.

The opposite reaction (3) is impossible to realize for free protons, due to the high endothermicity of 0.2714 MeV that requires a minimum temperature of 3.15 billion °K.

In the nucleus instead, the mass difference between proton and neutron disappears and reaction (3) balances reaction (1) with a kinetic constant the same order

of magnitude.

Reaction (2) is not important for stable nuclides but is relevant for unstable ones and for nuclear transformations with the positron β^+ reacting with the electron β^- in the annihilation reaction (5).

In what follows, the importance of reactions (1 - 5) for understanding the nature of Gravity, of the nuclear bond and for the first spark in the Sun will be evidenced in detail.

3. Gravity

Reactions (1 - 3) allow us to compute the neutrino ν_i emission per gram and second for all nuclei of mass a_i :

$$F_{oi} = \left(\frac{d\nu_i}{dt} \right) / a_i = \frac{+k_1 n_i + k_2 p_i + k_3 p_i^2}{a_i} \quad (6)$$

The value of F_{oi} is almost constant for all 1812 known nuclides and its mean value is **$F_o = 6.668 \text{ E}+20 \text{ v/g s}$** .

Every natural body emits a flux of neutrino proportional to its mass and it appears obvious to associate this elusive particle to the still unknown graviton that is thought to be responsible of Gravity.

Neutrino crosses the nucleons of a body without interaction and its mass μ is estimated $1.55277\text{E}-36 \text{ g}$ that is a temperature of $2.0362 \text{ }^\circ\text{K}$, lower that the measured $2.725 \text{ }^\circ\text{K}$ for the Cosmic Microwave Background.

The action of Gravity may be explained with a simple example: the Sun emits a flux of neutrino that spreads in the space with the inverse of the square of distance and cross the nuclei of the Earth without interaction; the neutrino emitted by the Earth in the direction of the Sun neutralize those received by the Sun while those emitted in the opposite direction sum up, giving rise to a momentum that pulls the Earth toward the Sun.

It is therefore possible, through an unconventional momentum balance, rewrite the Newton law at the table:

$$F = (F_o \mu c r_n^2 / 4m_n) Mm / r^2 = GMm / r^2 \quad (7)$$

where μ is the neutrino mass, c the speed of light, m_n the nucleon mass, r_n the nucleon radius and r the distance between masses M and m .

The Gauss constant G can be computed from the neutrino flux F_o :

$$G = (F_o \mu c r_n^2 / 4m_n) = 1\text{E} - 28 F_o \quad (8)$$

This strictly relates gravitation to intrinsic properties of matter and is not surprising, because Gravity is a property of matter and more specifically of nuclei.

Gravity is no more a mystery and the unexplained phenomena, described in [1] [3]-[6], find their solution.

Neutrino is the Graviton lacking in the standard model of particles, no need of inventing the phantomatic Higgs boson for Gravity.

The Sun loses, with neutrino, **$2.22\text{E}+30 \text{ g/s}$** and this phenomena is not consid-

ered in the Sun Standard Model [7], the neutrino, in some exciting form, being viewed only as tool for investigating the nature of minor nuclear fusion reactions.

The energy produced by fusion reactions, that heats our Earth and that we can measure from the surface temperature of 5800 K, has the enormous figure of 3.846×10^{26} W, but a minor mass loss of only **1.0678E+14 g/s**, if compared to the neutrino loss: the energy balance of the Sun must be reviewed.

Newton should be happy with this analysis and indeed he was lucky because, with reference to the Earth, the value of the neutrino flux ***Fo*** can be considered constant and fits perfectly the value of ***G***.

However, for light nuclei, as those encountered in the Sun, in the Stars, in the gaseous planet and consequently in the majority of the Universe, the neutrino flux per gram and second is reduced, compared to the emission of rocky planets, [3] and the mass of stars should be higher.

If the Sun is 70% Hydrogen and 30% Helium, the mean neutrino flux is **6.26 E+20 v/g s** against ***Fo* = 6.668 E+20 v/g s** and the mass of the Sun might be **2.12 E+33 g**, against the standard value, derived using Newton Law, of **1.9885E+33 g**.

Table 1 reports the neutrino flux of light nuclides, computed with Equation (6)

Table 1. Neutrino flux (v/ g s) for light nuclei in the Sun.

n	5.747E+20
¹ H	6.326E+20
² H	6.044E+20
³ H	5.958E+20
³ He	6.168E+20
⁴ He	6.096E+20

Therefore Newton Law cannot be considered Universal [3].

The influence of Gravity on the shape and energy balance of the Sun is large together with the important hydrostatic pressure effect on the hot plasma with an estimated density in the center of the Sun of 150 g/cm³, a temperature of 15.7 million °K (0.0035 MeV in energy units) and a pressure of 230 billion bars: the distance of protons is 2.23 E–11 cm, below the 5.30 E–11 cm of hydrogen atomic radius.

One may wonder which of the two, pressure due to Gravity or temperature due to strong nuclear interaction might be the cause or the effect for making the Sun shine.

The enormous energy spent and the high value of hydrostatic pressure due to gravity, compared to the relatively low thermal energy related to temperature, may solve the question.

However this question has oriented and is still influencing the research on fu-

sion during the current century.

4. Strong Nuclear Interaction

The strong nuclear interaction can be easily derived from the experimental data on the mass defect of a nucleus, that is the difference between their mass and that of its constituting protons and neutrons.

The binding energy between nucleons have been computed by semi-empirical correlations such as the Drop Model, known before the lessons of Enrico Fermi at the University of Chicago (1945) [8], in the times when he started the first nuclear fission pile (1942) and gave his valuable contribution to the Manhattan project for the nuclear bomb.

The hypothesis made, with the drop model, was that no difference exists between n-n, p-p and n-p bonds: the fitting of data is appropriate, with the exception of light nuclides [9], that are those present in the Sun.

Similarly to the deviation of light nuclides from the Newton model of Gravity, the nature of the nuclear interaction has not been explained, even with the aid of Quarks (question marks) and the imaginative Gluons.

Following the nuclear transformations of reactions (1 - 3), it has been shown [9] [10] that only neutron-proton (n-p) interactions exist and that the nucleons stick together sharing, in their formation, twice the mass lost (2.044 MeV) with reaction (5).

The exercise has been made to rebuild all stable and unstable nuclides till Neon and the fitting of all nuclides, using this mass loss, showed the number of nuclear bond asymptotic to the geometric value of 12, reduced for the contribution of nucleons staying on the nuclear surface.

It is important to note that virtual bonds are also involved in the synthesis of nuclides in order to provide space for their motion.

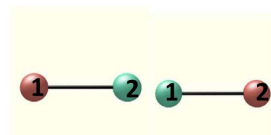
Another relevant fact is that, in nuclei, neutrons and protons, due to this mass loss, have similar masses and consequently can easily transform one into the other following reactions (1 - 3) while, for free protons, it appears impossible even in the Sun.

To assist the reader, the non-repeated changes and the resulting number of bonds of light nuclides, relevant in the Sun and in the fusion process, are reported with red figures.

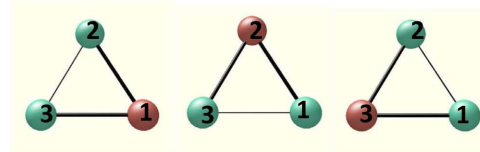
Note the surprisingly high number of bonds of lighter nuclides, that can be related to the dynamic behavior of the nucleus, and remained unexplained in the official literature.

In **Figure 1**, the two states of Deuterium ^2H with proton 1 bond to neutron 2 and neutron 1 to proton 2 (red numbers), resulting in one double bond, while for Tritium and Helium 3, we have three possible transformations

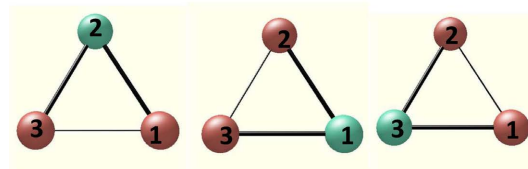
For Tritium ^3H , in the three possible combinations, we obtained 4 non-repeated bonds and for ^3He we get a similar result that is surprisingly in line with the experimental value of **Table 2** and explains also the slow decay of tritium ^3H to ^3He .

 ^2H

12 1
21 0 >1

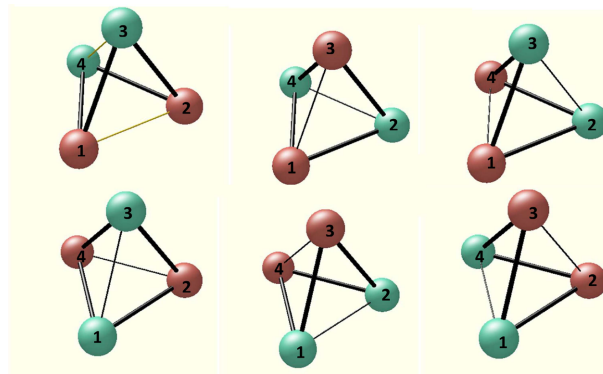
 ^3H

12 13 2
21 23 1
31 32 1 > 4

 ^3He

12 32 2
21 31 1
13 23 1 > 4

Figure 1. Number of dynamic bonds of ^2H , ^3H and ^3He .

 ^4He

13 14 23 24 4
12 14 32 34 2
12 13 42 43 2
21 23 41 43 2
31 32 41 42 2
21 24 31 34 2 > 14

Figure 2. Number of dynamic bonds of ^4He .

Coming to ^4He , the puzzle becomes clearer, as shown in **Figure 2**, where the number of dynamic states of the nucleus is six and the number of dynamic bonds

is 14, again in line with the experimental values reported in **Table 2** under the 2.044 MeV hypotheses. All these bonds are statistically present at the same time.

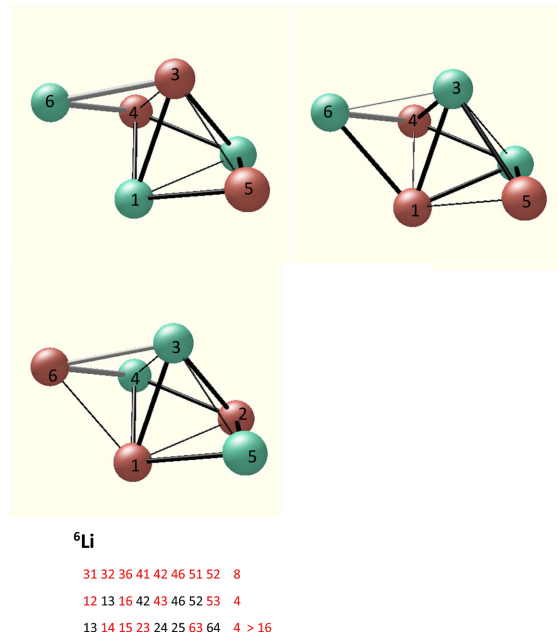


Figure 3. Number of dynamic bonds of ${}^6\text{Li}$.

One may derive the idea that the tetrahedron shape of ${}^4\text{He}$ should dominate the scene in all resonant shapes present during the nucleon dynamic transformations, as can be perceived for the stable nuclides of Li, of interest of this work, reported in **Figure 3**, **Figure 4**.

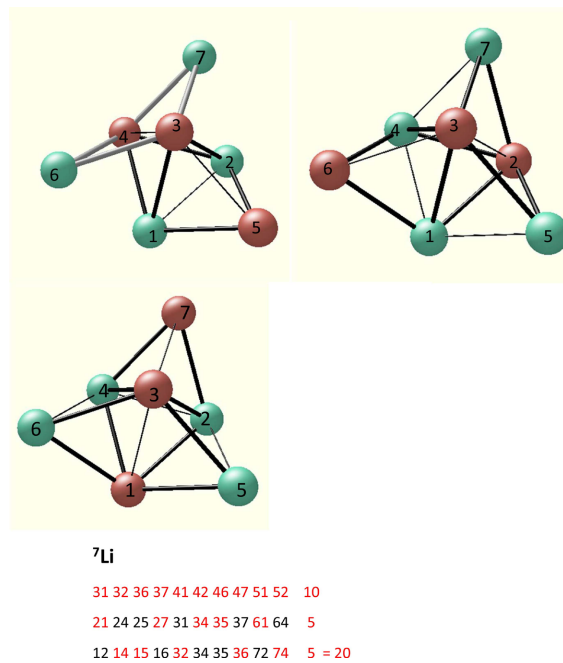


Figure 4. Number of dynamic bonds of ${}^7\text{Li}$.

Paper [9] shows that heavier nuclides follow the same rule and that this criteria of computing bonds solves the unexplained anomaly of light nuclides and, due to the $2Q = 2.044$ MeV mass lost, how easily protons and neutrons can interchange.

One can appreciate the dance of neutrons and protons in the nucleus and the consequent dance of electrons, following Equations (1 - 3), and may evaluate their stability: It is more difficult to react ${}^7\text{Li}$, that has two completed helium tetrahedron, than ${}^6\text{Li}$ that differ from ${}^4\text{He}$ by two pending nucleons.

Table 2 shows the number of bonds obtained by dividing the experimental mass defect by $2Q$, compared to the geometric computed value.

Table 2. Nuclear bonds from experimental and computed data.

Nuclide	N.bond	N.BOND
	experimental	computed
${}^2\text{H}$	1.135	1
${}^3\text{H}$	4.149	4
${}^3\text{He}$	4.172	4
${}^4\text{He}$	14.205	14
${}^6\text{Li}$	16.597	16
${}^7\text{Li}$	20.096	20

5. The Proton-Proton Chain Reactions in the Sun

The **proton-proton chain** represents the main known sets of nuclear fusion reactions by which stars convert hydrogen to helium, originally proposed by Arthur Eddington in the 1920s and then refined Hans Bethe who won the Nobel Prize in 1967.

The p-p initial reaction drives its origin from the difficulty for a free proton to run inverse reaction of neutron decay. As said, the problem is the 0.27415 MeV remaining in the difference between the mass of neutron and that of proton plus electron, that result in a temperature of 3.15 billion °K.

The first step in p-p branches is the fusion of two protons into a deuteron. As the protons fuse, one of them undergoes beta plus decay, converting into a neutron by emitting a positron and an electron neutrino:



The positron will annihilate with an electron from the environment into two gamma rays. Including this annihilation and the energy of the neutrino, with the net reaction:



This is a fictitious exothermic reaction, because one proton is transformed in a “light” neutron following β^+ emission reaction (2) and is suddenly captured in the weak nuclear cycle (1 - 3) to yield deuterium D.

It is the only way and the unique opportunity for the Sun to recover a neutron

and it is interesting to compare reactions (9, 10) with the classic buildup of deuterium D from a proton p and a neutron n with release of 2Q of energy corresponding to the formation of one nuclear bonds and two $\beta^+ \beta^-$ annihilations (5).

This is the rate-limiting reaction and is extremely slow and the constant k_2 (4) of reaction (2), now available, allows the estimation of the reaction time of 2.45 days for one n or D production.

From the value of power of 3.846×10^{26} W released by the Sun, one can compute the Helium atoms produced per second and the Deuterium produced with reaction (9) or the Hydrogen (proton) consumed with reaction (2). ($1.78034\text{E}+38$ atoms/s).

Dividing this figure by k_2 , one can estimate the number of protons p involved in these reactions that represent a small fraction ($4.26\text{E}-14$) of protons or hydrogen atoms present in the Sun and even a low portion of the high temperature and density inner core of the Sun ,where all nuclear reactions are supposed to be active.

After it is formed, the deuterium produced in the first stage can fuse with another proton to produce the stable, light isotope of helium, ^3He :



This reaction is estimated extremely fast due to the high concentrations of hydrogen nuclei and involves the creation of three new nuclear bonds, using “light” neutrino, and energy less than 6.066 Mev, accounting the new bonds formed.

The production of ^4He is supposed to be mainly due to the fusion of two ^3He with a release of two ^1H atoms and is thought to be very slow

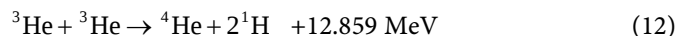


Figure 5 reports the proton-proton scheme derived by Wikipedia [11] where reactions (9) and (11) occur twice to yield two ^3He nuclei with the final result that four protons are combined to form an alpha particle.

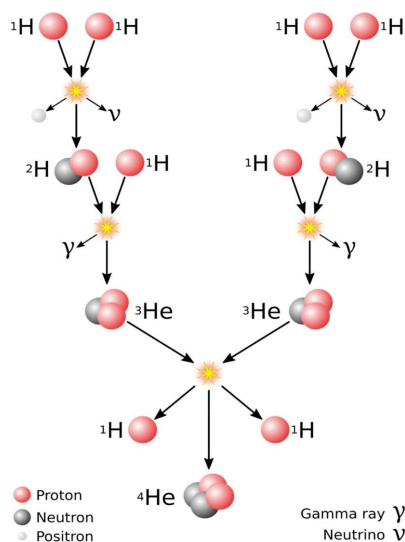


Figure 5. Literature Cycle of the main reactions in the Sun [11].

This scheme is apparently incomplete due to the lack of information about the nature of the nuclear bond and the emission of neutrino by matter, due to the still unknown Gravity.

The strong nuclear interaction has always been thought to give the highest energy contribution to the Sun but the knowledge of the intensive work of gravity changes this perspective: the thermal energy available at the maximum temperature in the Sun is a small 0.00135 MeV, insufficient alone for fusion.

That is why researchers strive to increase temperature in fusion reactors forgetting that heat release may be a consequence and not the cause of fusion.

As far as the present paper is concerned, some revisions should be made on the model of the Sun and to the idea of reproducing the Sun on Earth.

In his review on the Standard Model of the Sun, Bahcall [7] reports the long investigations made by nuclear scientists, from 1962 till the year 2003, to model the various hypothetical additional reactions and to fix them by kinetic cross section experiments and neutrino measurements.

It is apparent that measuring the cross section in the lab is very different from the conditions existing in the Sun because of the different and higher velocities in the lab compared to those of the high density plasma in the solar core.

Bahcall confesses his skepticism and doubts and *hopes that in the next ten years a better understanding of neutrino physics will provide new surprises and nature will disclose what at the time was hidden to us.*

This gave us the courage to review the physics of the Sun and to propose again our view on the unification of natural interactions.

6. Nuclear Fusion on Earth

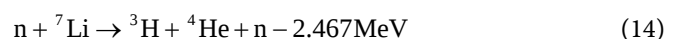
The first full-scale thermonuclear fusion test was carried out by the United States in 1952, just few years later the realization by Enrico Fermi of the first fission reactor (1942) and the Manhattan project of the nuclear fission bomb (1945).

Modern fusion weapons essentially consist of two main components: a nuclear fission primary stage and a separate nuclear fusion secondary stage containing thermonuclear fuel isotopes of hydrogen (deuterium and tritium).

The first fission stage provides the temperature and pressure to activate the second fusion stage, which is shielded from neutrons to avoid predetonation.

This way, the first difficult step (9) of the p-p cycle of the Sun is bypassed and ^3He is replaced by the equivalent ^3H , more convenient for a higher cross section, but still unavailable in nature.

Deuterium ^2H can be extracted from heavy water, while tritium ^3H can be obtained from Lithium:



The fusion process, reported in **Figure 6**, is simpler than that described for the Sun and has the advantage of producing a neutron for eventual use in tritium

production.

Apart from the difficulties and costs to recover the fuel, we can easily understand the big differences for the realization of a fusion reactor compared to a fission one.

When Enrico Fermi realized the first fission pile, he could easily arrest the neutron chain reaction, inserting the control bars and having dinner; the neutron flux reaction was then reactivated by extracting the control bars.

The fusion reactor instead works like a combustion engine where the deuterium-tritium fuel is fed, producing Helium and one neutron that can hopefully be used to generate additional tritium through reactions (13, 14).

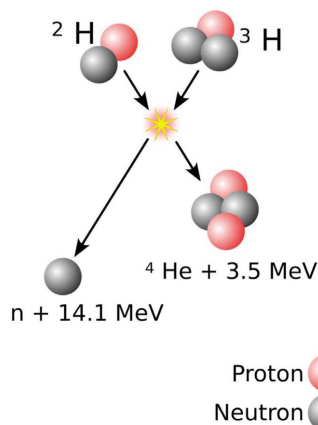


Figure 6. Fusion process from Wikipedia [12].

The expected operating conditions, pressure and temperature should be very severe if we want win the plasma ion repulsion and approach the operation of the Sun.

At the beginning, it has been assumed that the cause of fusion was uniquely squeezing Hydrogen atoms similarly to the action of Gravity in the Sun.

Therefore the idea of realizing a “cold” fusion at ambient pressure and temperature dominated the end of last century starting with the idealized patent of Fleischmann and Pons (1989), using deuterium electrolysis, and ending with the experiment of Arata and Chang (2008), pressurizing deuterium at 50 bars in tubes containing metal nanoparticles.

The basic idea in all the experiments, to simulate the squeeze of Hydrogen atoms, was the use of particular metals like Palladium, Nickel or Zirconium able to absorb great quantities of deuterium, to a molar ratio of 1, in order to simulate, in condensate phase, high pressures.

When “cold” fusion was abandoned due to poor results and recognized scale up problems, the research has been shifted toward the already active opposite direction of high temperature and low pressure, being impossible to confine the plasma by Gravity, as the Sun does, or by the inertial pressure as in the hydrogen bomb.

The conceptual approach, that aims the simulation of an eventual industrial

fusion reactor, is represented by the **tokamak**, a device which uses a magnetic field to confine plasma in the shape of an axially symmetrical torus.

The first tokamak was built in the Soviet Union in 1954 but it took a long time to recognize the problems of plasma instabilities, activating and maintaining the elevated temperatures for fusion, interaction of hot plasma with the reactor walls and generating extreme reactor vacuum.

In yeas 1970s a tokamak basic design was available and a dozens of tokamaks were in use around the world with leading facilities as the **Joint European Torus (JET)** and **Tokamak Fusion Test Reactor (TFTR)**, for making fusion tests and find necessary conditions for practical application.

However, as in the case of cold fusion, through the mid-1980s the reasons for many of the perceived problems became clear, and various solutions were offered; these resulted in the increase the size and complexity of the machines. A follow-on design incorporating these changes would be both enormous and vastly more expensive than either **JET** or **TFTR**. A new period of pessimism descended on the fusion field.

The commercial availability of high temperature superconductors, in the 2010s, opened a promising pathway to building the higher field magnets required to achieve ITER-like levels of energy gain in a compact device.

We come to these days with a renewed enthusiasms and hope but with the gained awareness that obtaining clean and cheap energy is not so easy and still represents a dream projected in the far future.

The realization of the new large version of ITER at Cadarache (France) is expected In 1935 but is still thought to be a research facility to demonstrate the feasibility and the duration in time of fusion.

The opinion of ITER engineers is that these reactors are very difficult to build and to run due to:

- The high vacuum of the chamber and the stability of the torus at 150 million degrees Celsius (0.0129 MeV), acting on the magnets to avoid the interaction of the plasma with the walls of chamber;
- The use of special superconductors cooled at -269°C to produce a magnetic field around 11 Tesla and the necessary liquid Helium cryogenic plant.
- The systems to pre-heat the plasma with hot neutral injected particles and microwaves, with the feed of at least 50 MW to start the fusion and obtaining 500 MW thermal energy.
- Extracting the hot fluid and exchanging heat is also a non-trivial operation.

For details on ITER project one can find the basics of IAEA in reference [13] and a well done overview of Wikipedia [14].

ITER is the project with more history, but there are many competing project based on the Tokamak concept and on the Deuterium-Tritium reactions spread in different world nations.

Other technologies (e.g. heating small samples with laser) or using different and higher ignition temperatures nuclear reactions have been investigated.

One must agree that we are far from the simplicity and ease of the first fission reactor and we must be satisfied with the obtained 15 - 20 minutes of operation of ITER, but the realization of an industrial electricity production plant is long in the future.

The similitude with the Sun is in any case lost: the Sun is hardly producing one neutron per p-p reaction, operates semi-batch wise discharging neutrinos, while on the Earth we bypass the first step and feed neutrons together with deuterium and tritium produced apart.

Moreover, with the exception of the nuclear bomb, the operation is at high temperature but under vacuum, instead of the 235 billion bars provided by gravity in the core of the Sun.

The feed is however, very small: for a 1000 MWt reactor we need about 10 g/h of a 50% D + T mixture and, considering the energy lost for moving a large ITER production facility, we might need even 30 g/h of material, that is sufficiently small and might be comforting, even considering the high costs of production.

The neutrons involved are 7.09262×10^{20} n/s and those fed with Tritium could be theoretically recovered in the reaction or partially integrated with an additional production with a fission reactor blanketed with Lithium, whose neutron production at 1000 MWt is however about 1×10^{20} n/s.

The high disproportion between material, having enormous specific energy content, to be processed in high reaction volumes, requires an accurate control of the fluid-dynamics of the reaction plasma together with a precise knowledge of the nuclear reaction rate in function of temperature and pressure, that is the cross section of D + T reaction, their nuclei kinetic energy and their volume concentration.

Some public and private institutions are developing technologies alternative to Tokamak, even using different fusion reactions with higher ignition temperature, but Tokamak remains the best chance for demonstrating, with a sophisticated technology, the possibility of maintaining a stable fusion process: for the realization of an industrial reactor, we might have to wait at least for the next 20 years and possibly to realize some engineering simplifications.

The extreme vacuum and plasma magnetic control technique can be seen as the daughter of the complex technologies realized for basic research on gravitational waves, neutrino capture and velocity measurement and new sub-particles identification with cyclotron, but one must avoid that technology becomes self-referenced.

On the Earth there is abundance of medium and high energy neutrons and their direct use in nuclear fusion reactions should be better investigated for obtaining locally the high temperature-energy needed, without involving the bulk of fluid in the reactor.

In the already cited [8] Halpern revised lessons on the physics of neutrons, dated 1945, the production and the reactions of neutrons are extensively treated but, with the exception of the technology improvements in fission reactors, the

theory is not changed.

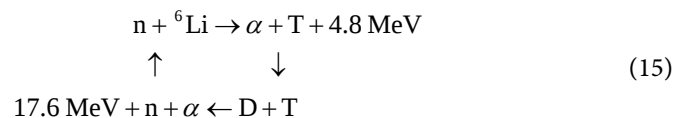
The effect of neutrons on fusion reactions has been recognized for the hydrogen bomb: the lead shield to avoid premature explosion and the surprise of the increase of power due to the endothermic reaction of ${}^7\text{Li}$ with fast neutrons are examples.

The use of fission reactors for the production of Tritium for the bomb has been a common practice while the byproduct Deuterium and Tritium obtained in some of them has not been considered due to the small quantities.

A number of research facility and even small fission reactor for the production of neutrons and making experiments on nuclear reactions have been built but the proposal of developing a technology for a fusion reactor activated by neutrons has not been advanced.

The suggestion to consider Lithium Hydride (LiH) and Li Deuteride (LiD), as a compact starting fuel for fusion, appeared from time to time and recently a team of researchers [15] recovered this Idea from older works, using neutrons as activators-catalysts at ambient temperature but with sufficient energy to realize fusion locally.

LiH and LiD are stable compound but react with neutrons and provide locally the basic ingredients of Li-n reactions and the simultaneous fusion T-D, with recovery of neutron:



The authors strive to analyze additional reactions involved, evidence the lack of information on these topic and invite researchers to perform experiments in this direction, due to the high feasibility of the industrial application.

The availability of a suitable neutron flux and neutron dispersion might be a problem but this should not happen if LiD is used as a reacting or cooling fluid in a fission reactor.

LiD is a moderator for neutrons and is fluid at 900°C , similarly to Sodium, used as a cooling fluid in the Cadarache successful Phoenix and Superphoenix project.

Maybe the prototypes Cyrano and Rapsody are still there and could be used, together with available expertise, for the preliminary tests.

On the other hand, there are a myriad of small fission reactors spread in various centers of the world dedicated to experiments on neutron applications: fission reactors appear to be the most available candidates for the production of neutrons together with energy, similarly to the fission bomb that is the more convenient mean for activating the fusion bomb.

7. Conclusions

The revision of the new ideas on electroweak, gravity and strong nuclear binding energy allows the unification of the main natural interactions and gives the most

complete picture of the effort of the Sun to generate the first neutron of the universe and build up light nuclei.

Gravity has been shown to be the main reason for aging of the Sun, while the strong nuclear interaction, with emitted radiation, gives a minor contribution to its mass loss.

Gravity is also the main actor for the initial spark for activating the nuclear reactions and making the Sun shine.

The weak interaction and its newly defined reaction constants allow the computation of the d-d reaction and to locate this reaction in the inner core of the Sun where the more severe pressure and temperature conditions are present.

These conditions should therefore be more severe than those required by successive reactions.

This encouraged the fusion on Earth, where neutrons are available, the bypass of the p-p step is possible, and the successive steps appeared favorable: the tritium-deuterium reaction has been preferred due to the higher cross section.

The simpler approach was the cold fusion, at low temperature and pressure, with the hope that hydrogen in the condensed phase on particular metals could help in simulating the high pressures.

After the recognized failure of cold fusion, attention has been captured by the low pressure-high temperature approach in plasma state.

The analogy with the Sun was again lost for the extreme vacuum used and the excessive temperature, about ten times that estimated for the center of the Sun.

The plasma has been confined in an electric-magnetic field, and the improvements of high vacuum and superconductors gave the courage to implement the ITER project.

This is a fantastic dream for research, but in view of industrial application, maybe the engineering approach of Enrico Fermi and his colleagues should be reconsidered when they started the first fission reactor and a few years later gave their contribution to the fission and the fusion bomb: similarly to the bomb, combining a fission and a fusion reactor is suggested.

The conditions may be different from those of the Sun, but we have plenty of neutrons available, while the Sun is striving to generate one neutron from one proton.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Notation

F	Newton attraction force (g cm/s ²)
G	Gauss constant (6.668E-08 cm ³ ·s ⁻² ·g ⁻¹)
M, m	masses (g)
R	distance (cm)
μ	neutrino mass (1.55277E-36 g)
ν	neutrino number
γ	gamma ray (MeV)
F_0	mean neutrino flux (6.668E+20 ν /g s)
F_{oi}	neutrino flux of single nuclei (ν /g s)
m_n	nucleon mass (1.67548E-30 g)
r_n	nucleon radius (1.95247E-17 cm)
c	speed of light (cm/s)
n	neutron
n_i	neutrons of nucleus i
p	proton
p_i	protons of nucleus i
a	atomic mass (g)
a_i	atomic mass of nucleus i
no	number of nuclei examined
β^+	positron
β^-	electron
α	alpha particle, Helium
k_1, k_2, k_3	constant in Equation (5)
H, ¹ H, ² H, ³ H, D, T	Hydrogen and Hydrogen isotopes, Deuterium and Tritium
He, ³ He, ⁴ He	Helium and Helium isotopes
Li, ⁶ Li, ⁷ Li	Lithium and Lithium isotopes
LiH, LiD	Lithium hydride, Lithium deuteride