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The Rocky Planets' Magnetic Field: A New Parameter for the Drake's Formula

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Abstract

The Drake formula is a statistical method of forecasting the possible number N of technically evolved extraterrestrial and galactic civilizations able to communicate with the human species. It is based on seven different factors that can be grouped into factors of type A, f_A ("Astrophysicist") and type B, f_B ("Astrobiological"). The quantitative analysis of these factors at the time of the presentation of the formula was subjective and highly variable for both factors f_A and f_B. Current scientifical and technological development has made it possible to refine the quantitative estimates of the f_A group whose definition is now less uncertain. In group f_A the parameter n_e is understood as the number of planets capable of sustaining life. By means of n_e Drake defines this possibility exclusively from the geometric point of view. In particular, the planet's orbit must be included in the circumstellar space in which the planetary temperature allows the presence of liquid water. This is not enough because, for liquid (and gaseous) water to be present on the planet's surface, it is also essential that the planet has a magnetic field of adequate intensity to shield the flow of charged particles coming from its star (solar wind). The solar wind is able to break up and disperse the liquid and gaseous water molecules and any organic molecules in times much shorter than theoretically necessary for the formation of life and above all, except for singularities, than necessary for evolution to arrive at intelligent life. Here the planetary magnetic field parameter n_m is introduced into the Drake formula and its statistical probability of existence is discussed.

Keywords

Drake's Formula, Magnetosphere, Solar Wind, Extraterrestrial Intelligent Life

1. Introduction

According to Drake's formula, the number N of civilizations capable of produc-

ing interstellar communications depends on seven statistical factors:

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L \quad (1)$$

where

$N \rightarrow$ number of planets in the Milky Way with technologically advanced civilizations;

and where (f_A astrophysical factors)

$R \rightarrow$ average annual rate of new star formation in the Milky Way;

$f_p \rightarrow$ percentage of Milky Way stars owning planets;

$n_e \rightarrow$ average number of planets per planetary system able to host life forms;

and (f_B astrobiological factors).

$f_l \rightarrow$ planets where life actually developed;

$f_i \rightarrow$ planets on which intelligent organisms have evolved;

$f_c \rightarrow$ extraterrestrial and galactic civilizations technologically capable of interstellar communications;

$L \rightarrow$ estimate of the longevity of the f_c-class galactic civilizations.

The presence of a planetary magnetic field is not included in the f_A group. But the presence of the planetary magnetic field seems essential for the development of life and even more so to allow simple life to evolve into an intelligent one. Observation of solar activity shows that the star emits, together with energy in the light band (and other ones), a series of charged sub-atomic particles, mainly H^+ protons (≅95% of the total mass of the solar wind) and a fraction of lower density consisting of electrons e^- (≅4% - 5%) and complex ions (**Table 1**). These charged particles interact magnetically with the Earth's magnetosphere [1] [2] [3].

In the low solar activity days (Q = quiet days), the ionized material moves from the solar chromosphere toward the outer space with a speed $v \cong 200$ - 300 km/sec. In the days of disturbed solar activity (D = disturbed days) v can reach, and in some cases exceed, about 500 km/s (e.g. the material emitted by a flare, in dynamic conditions of HSSWS high speed solar wind stream) [4].

Table 1. Solar wind parameters in Q (quiet day) condition at distance $d = 1$ [AU]. δH^+ density of the protons, $\delta\Phi$ flux density of the solar wind (Q days), $v_{(H^+)}$ average speed of the constituent particles of the solar wind, $T_{(H^+)}$ temperature of the protons, $T_{(e^-)}$ temperature of the electrons, F intensity of the "chained" magnetic field (associated with the solar wind).

δH^+	10 [cm^{-3}]
$\delta\phi$	3×10^8 [$cm^{-2} \cdot sec^{-1}$]
$v_{(H^+)}$	$3 - 5 \times 10^2$ [$km \cdot sec^{-1}$]
$T_{(H^+)}$	4×10^4 [K]
$T_{(e^-)}$	1.5×10^5 [K]
F	4 [nT]

The solar wind on both days Q and D, if not shielded from the planetary magnetic field, would reach the surface of the planet [5]. This physical condition can generate at least two lethal effects for the hypothesis of life (even before intelligent life):

- direct and destabilizing interaction with the structure of organic molecules;
- destructuring interaction with liquid and gaseous water molecules;

water and organic molecules would be swept away from the planet's surface which would be sterilized [6]. This effect heavily affects the statistical evaluation proposed by Drake and therefore the probability of the presence of the planetary magnetic field must be inserted in the formula as factor n_m (planetary magnetic field). n_m represents the percentage of rocky planets that possess a magnetic field of suitable intensity to shield the solar wind.

2. The Revision

To improve the effectiveness of Drake's formula (1), the inclusion of the w (water) parameter is proposed. The parameter w includes the geometric evaluation parameter n_e (distance star-planet) and the electromagnetic one n_m

$$w\begin{cases} n_e \\ n_m \end{cases} \rightarrow w = n_e \times n_m \tag{2}$$

from which

$$N = R \times f_p \times w \times f_l \times f_i \times f_c \times L \tag{3}$$

or in expanded form

$$\begin{cases} N = R \times f_p \times w \times f_l \times f_i \times f_c \times L \\ w = n_e \times n_m \end{cases} \tag{4}$$

$$N = R \times f_p \times n_e \times n_m \times f_l \times f_i \times f_c \times L \tag{5}$$

In the original version of Drake's (1) proposal, w is equivalent to n_e. This one is a geometric datum (star-planet mean distance) well known but insufficient to declare the planet potentially habitable.

The role of the factor n_m in the factors F_A group and therefore in the formula can be formalized by the following limits (6), (7):

$$\lim_{n_m \to 0} w = 0 \tag{6}$$

from which

$$\lim_{w \to 0} N = 0 \tag{7}$$

without the availability of n_m it is not possible to predict the lasting presence of surface liquid water and therefore to produce a plausible value of N. The problem evolves in the statistical prediction of the presence of a "Earth-like" planetary magnetic field and therefore of the presence of a magnetic generator inside the planet (5). In other words, the question is: is the Earth's magnetic field a typical element of rocky planets or is it a singularity linked to the formation of the planet Earth [7] and therefore of its internal structure?

3. About the Planetary Magnetic Fields and Their Probabilty of Existence

The Earth's magnetic field (or geomagnetic), observed for sufficiently long times and sufficiently large spaces, can be modeled for more its 80% with a dipole placed at the center of the planet. Today the Earth's dipole is inclined by about 11˚ with respect to the planet's rotation axis and has an approximate magnetic moment of 8×10^{22} [Am^2]. The pressure of the solar wind and its chained magnetic field (also called IMF Interplanetary Magnetic Field) deforms the Earth's magnetic field by crushing the lines of force facing the sun towards the surface of the planet and stretching outward the lines of force oriented in the opposite direction (magnetotail) (**Figure 1**). To oppose the solar wind, the geomagnetic field must be particularly intense in the planets that orbit in the circumstellar space belt with a temperature compatible with the presence of liquid water. In fact, this thermal condition occurs only in the vicinity of the star (Sun type) where the flow of charged particles of stellar origin is still very intense.

The charged particles that make up the solar wind [8] are captured by the Earth's magnetic field and discharged to outer space through the magnetotail without reaching the planet's surface [9]. H^+ and e^- (main constituents of the solar wind) move along the magnetotail' lines of force towards the outside with a precession motion (H^+) or a co-precession one (e^-) (**Figure 2**). The border area between the solar wind's magnetic field and the Earth's magnetic field is called the magnetopressure zone. It approaches or moves away from the surface of the planet depending on the intensity of the flow of ionized particles emitted by the sun (**Figure 1**). To try to establish if this magnetic shield is typical of planet Earth or is typical of rocky planets, let's observe at some of its main characteristics.

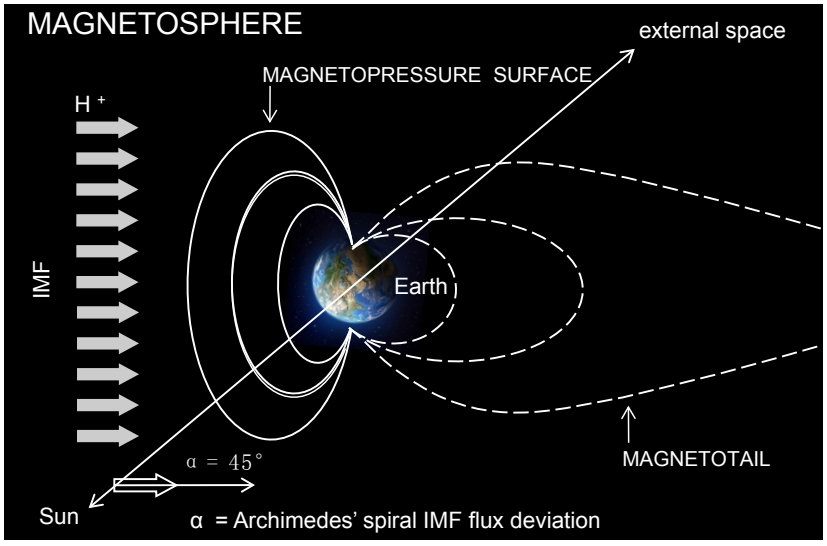

Figure 1. Earth's magnetosfere. IMF Interplanetary magnetic field, φ direction of IMF respect to the Sun-Earth direction (Archimedes' spiral effect), Magnetopressure surface is the border surfece between the solar wind associated magnetic fild and upper Earth's magnetosphere, magnetotail is the open structure of the magnetosphere opposit to the solar wind direction.

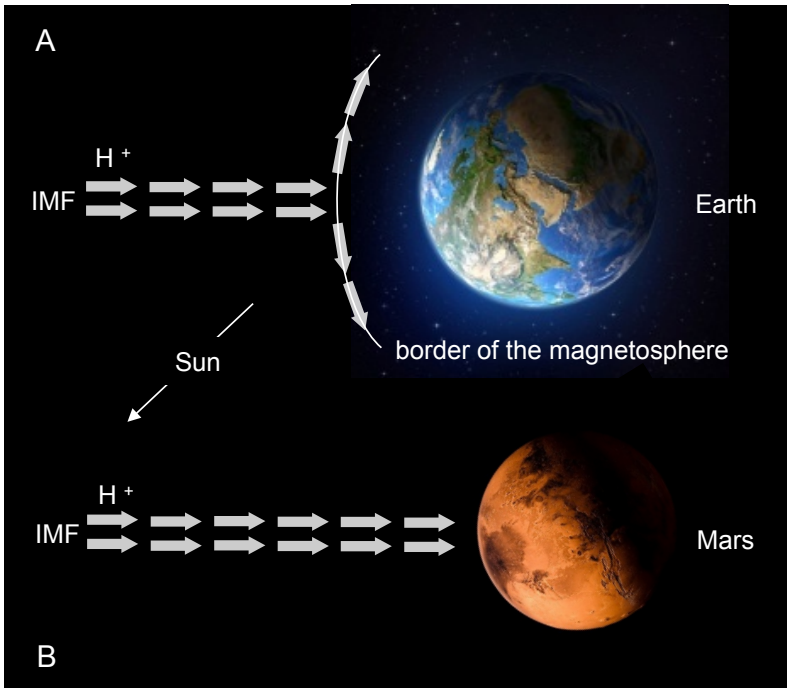

Figure 2. The electromagnetic relationship (A) Earth-Sun and (B) Mars-Sun. IMF Interplanetary Magnetic Field. (A) the solar wind is deflected by the magnetosphere, it moves along the magnetotail and does not hit the surface of the Earth, (B) the solar wind has not electromagnetic obstacles, it move along his original direction and hits the surface of Mars.

The intensity F of the geomagnetic field at the Earth's surface level depends on two components: the component of planetary origin F_E and the component induced on F_E by the solar F_{IMF} (8) [10]

$$F = F_E + F_{IMF} \tag{8}$$

the F_E component is the planet's magnetic shield. F_E is in turn made up of three main contributions, two natural (F_n and F_c) and one artificial (F_{mm}).

$$F_E = F_n + F_c + F_{mm} \tag{9}$$

where

F_n = magnetic field generated by the Earth's core (**Figure 3**);

F_c = magnetic field generated by the rocks of the Earth's crust;

F_{mm} = magnetic field generated by human activity (technologically developed civilization—man made component).

3.1. The Man Made Earth Magnetic Field Component F_{mm}

The F_{mm} (man made) presence in the Earth's magnetosphere is perhaps the best objective proof of human technological activity and therefore of our civilization development actual level. This F_E component has been studied and measured with great precision for several decades [11]. F_{mm} is essentially generated by the production, transport and use of electricity. Magnetic disturbances generated by power plants and those connected to power lines (especially alternating current

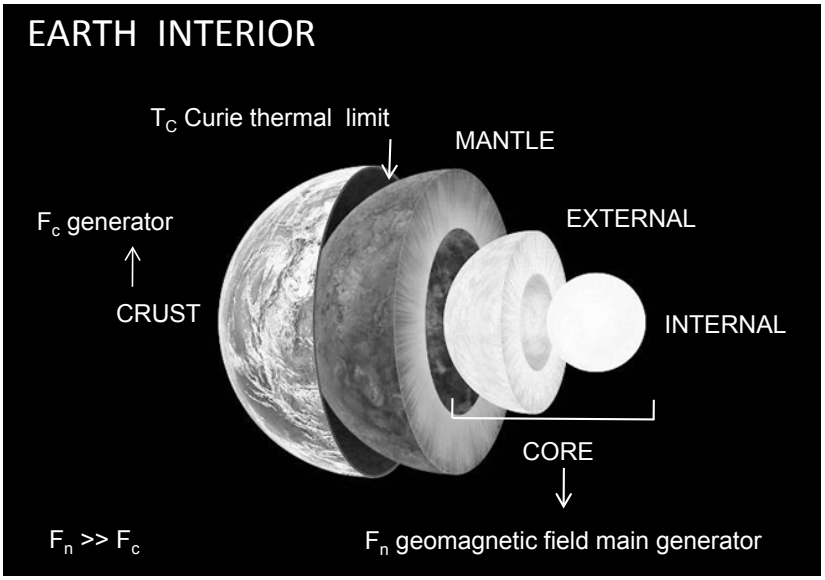

Figure 3. General view of the Earth's interior. F_n generator is the source of the main part of the geomagnetic field caming from the electro-dynamic relationship between internal core (solid state) and externa core (liquid state), F_c generator is the source of the secondary geomagnetic field caming from the magnetic properties of the crust's minerals (Weiss dominions' effect), T_C thermical limit of the Weiss dominions magnetization. The mantle has not magnetic effect [from http://www.blueplanetheart.it/2018/07/, modified].

and high voltage) are a well-known example. The electrified railway lines produce alterations in the magnetic field that are clearly legible tens of kilometers away and urbanization also contributes in a not insignificant way to the establishment of F_{mm}. **Figure 4** shows an example of a magnetic field F_{mm} (black line) measured in the La Spezia's port area (ITA). The comparison with the magnetogram recorded at the reference station "0.1-A M. Muzzerone" (red line) filtered for LP = 1 [Hz] shows that already at the distance $d \cong 3$ [km] the maximum part of F_{mm} is extinguished [12]. These magnetic effects, relevant for detailed studies, are however too local, too close to the surface of the planet and with too low intensity F to have significant effects in the solar plasma flux planetary deviation if not, perhaps, in the case of high proximity to the source. The magneto pressure surface (**Figure 1**) is too far from the surface of the Earth and the intensity of F_{mm} is too low to assume that F_{mm} is an effective part of the Earth's magnetic shield.

3.2. The Natural Magnetic Field F_c e F_n Components

Shown that F_{mm} does not concretely participate in the built of the Earth's magnetic shield, it is obvious to conclude this Earth electromagnetic capacity is of natural origin. Still in an attempt to establish whether this property is common to other rocky planets (assuming that these planets are the only ones capable of sustaining life), we observe the two main contributions of the geomagnetic field F_c (crustal) and F_n (nuclear). In geophysics these fields are roughly defined as the main field (**Figure 5**) and the anomaly field. They can be separated by a numerical

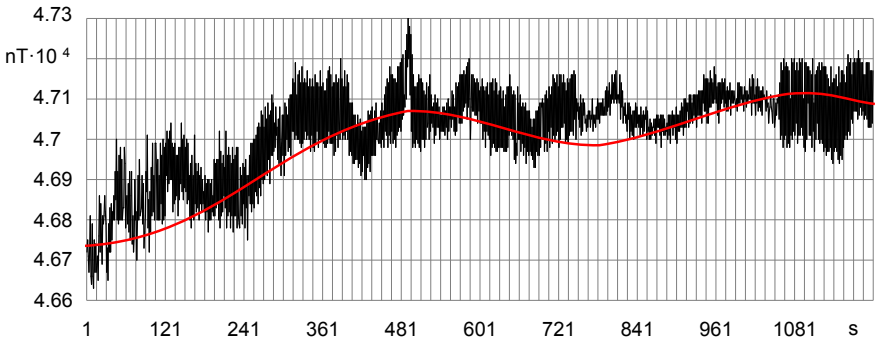

Figure 4. Total intensity magnetpgrams F. Black line from geomagnetic station of La Spezia port (acquisition sample rate = 10 [Hz]), red line from reference station of M. Muzzerone (φ = 44˚03'39.72"N, λ = 09˚49'43.95"E). Reference magnetogram: acquisition sample rate 10 [Hz], graphyc restitution LP filter 1[hz]. Highest intensity $F_{mm}^{480} = 21$ [nT] (from [12] modified).

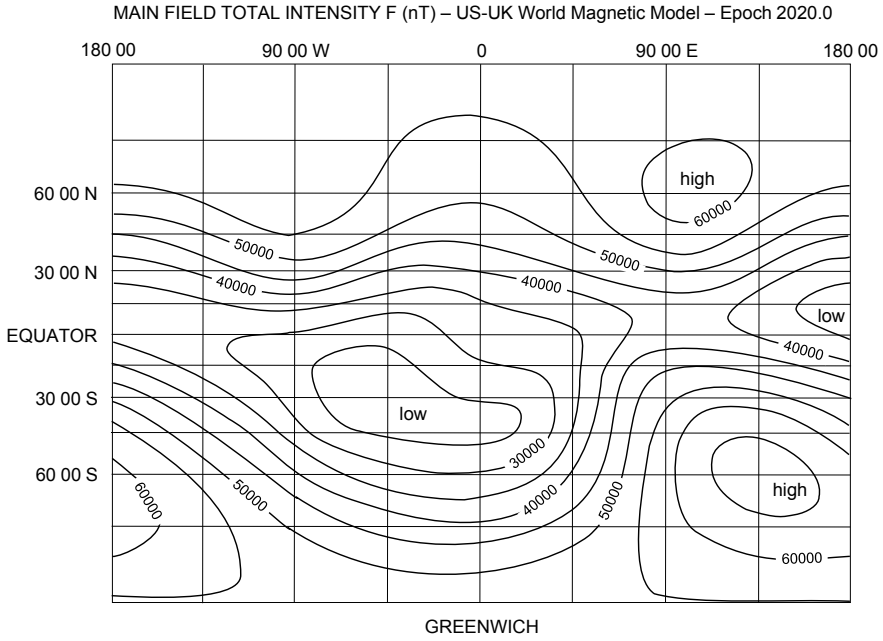

Figure 5. US-UK World Magnetic Model—Epoch 2020.0—Main Field Total Intensity F [nT]—Stars: geomagnetic poles: mN magnetic North, mS magnetic South. Map developed by NOAA/NCEI-CIRES https://ngdc.noaa.gov/geomag/WMM—(Publ. 2019)—(modified graphics).

reference model called IGRF (International Geomagnetic Reference Field). IGRF is a model of the main magnetic terrestrial field and its annual variations (secular variation).

On the Earth's surface and in the magnetosphere the main field is the negative gradient of a scalar potential V

$$F_{(r,\phi,\theta,t)} = -\nabla V_{(r,\phi,\theta,t)} \tag{10}$$

represented by a truncated harmonic expansion (currently the density of the experimental data allows a development of order 13).

$$V_{(r,\phi,\theta,t)} = a\sum_{n=1}^{M}\sum_{m=0}^{n}\left(\frac{a}{r}\right)^{n+1}\left[g_n^m(t)\cos(m\phi)+h_n^m(t)\sin(m\phi)\right]P_n^m(\cos\theta) \quad (11)$$

where

a = 6371.2 km;

N = 13 (higher expansion degree);

ϕ = longitudine;

θ = co-latitudine;

g_n^m, h_n^m = Gauss coefficients;

m, n = order and degree;

$P_n^m(\cos\theta)$ = Legendre polynomials;

r = harmonic function radius.

The observation of the power spectrum of an aerial circum-parallel survey of the geomagnetic field (**Figure 6**) has shown a very particular behavior of the generating source. It is different from the dipole which approximates it by 90% [13]. The F's power is distributed in three spatial frequency bands:

- low frequencies (deep sources): high powers;
- intermediate frequencies: approximately zero power with very low information capacity [11] (absence of medium depth sources);
- high frequencies (surface sources): moderate powers (**Figure 7**).

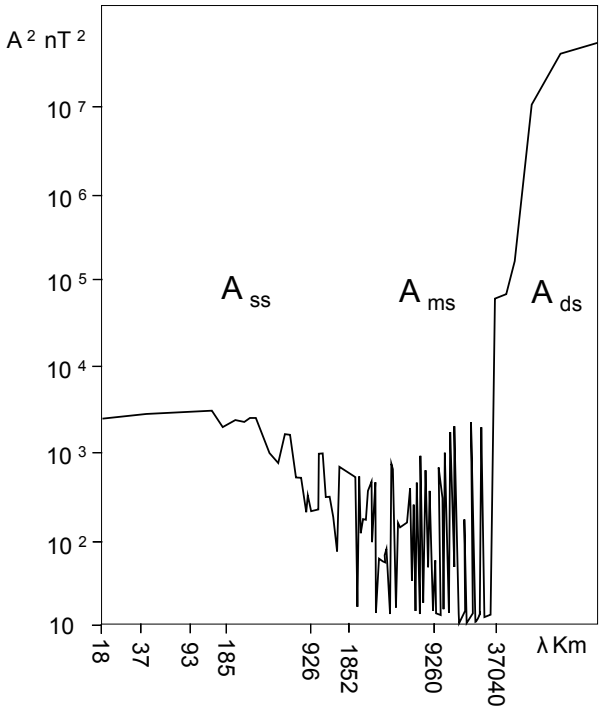

Figure 6. Power spectrum of the circum-equatorial equatorial aereomagnetic survey. X wavelngth, Y power $A^2 = a^2 + b^2$ with a and b Fourier's coefficients. A_{ds}^2 power generated by deep sources (core), the A_{ss}^2 power generated by surfacial source (crust), the A_{ms}^2 power is about zero. $A_{ds}^2 \gg A_{ss}^2$. Logaritm scale. The geomagnetic field power is caming from the spectral bands $\lambda < 500$ [km] or $\lambda > 3000$ [km]. From [12] (modified graphyc). Logaritmic scale.

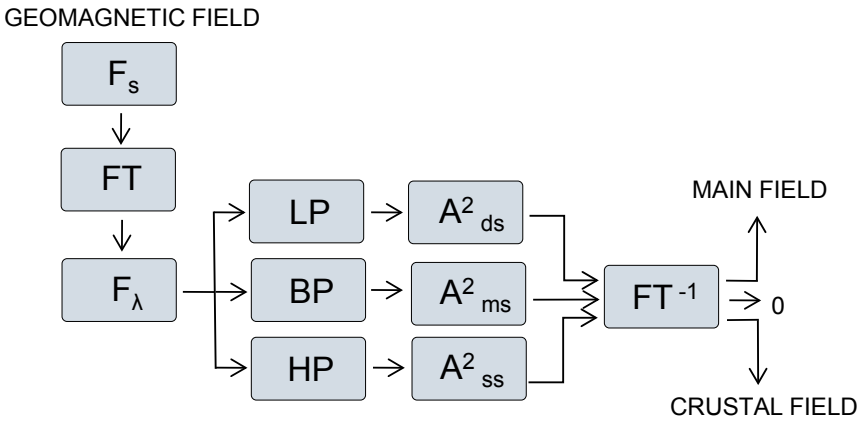

Figure 7. General flux diagram of Fourier computation of the deep, medium and superficial pawer contributes of the geomagnetic field power. Fs intensity of the geomagnetic field expressed in the space dominion (measured), FT Fourier Transform, f_λ intensity of the geomagnetic field expressed on wavelenght dominion, A_{ss}^2 superficial contribute (crust), A_{ms}^2 medium contribute (mantel)—about zero, A_{ds}^2 deep contribute (core).

where (Fourier transform)

$$f_{(\lambda)} = \frac{a_0}{2} + \sum_{n=1}\left[a_n \cos(n\lambda) + b_n \sin(n\lambda)\right] \tag{12}$$

and

a_n, b_n = Fourier coefficients;

$A^2 = a_n^2 + b_n^2$ = power;

A_{ss}^2 = surface sources power (crust);

$A_{ms}^2 \cong 0$ = power of medium sources (mantle);

A_{ds}^2 = deep sources power (core);

f_λ = geomagnetic field in the wavelength domain (spectrum);

F_s = geomagnetic field in the space domain.

This behavior is explained by the different physical origin of F_c and F_n. F_c is generated by the magnetic characteristics of the crystals (Weiss domains) making up the rocks of the Earth's crust and is well known and modeled [14]. The magnetic activity of the Weiss domains, seat of the magnetism of the crystals, ceases above a specific temperature of each crystal (Curie T_C temperature). The crystals composing the crust subjected to a $T \geq T_C$ lose their magnetic properties. The main part of the Earth's magnetic shield is not made up of the A_{ss} component from the solid state of the Earth's crust because this portion of the planet produces an inherently weak magnetic field and has too thin active magnetic thickness (confined by T_C depth). On the other hand the circumparallel aeromagnetic profile spectrum clearly shows the power generated in the intermediate part of the planet (2900 - 5000 km of depth) is irrelevant for the geomagnetic field constitution and therefore the electromagnetic generator must be located in the core of the planet. The planet has an effective magnetic shield against the solar wind not because it is rocky but because it has deep magnetic sources. These sources are electromagnetic ones and their activity limits are not bound to the T_C

deep.

It is not enough the planet is of a rocky type one for it to also have a magnetic field F strong enough to deflect the stellar plasma flux.

Two characteristics are necessary for the rocky planet to be able to sustain life: a) its orbit must always be at the right distance from the star, and b) it must have a magnetic shield capable of deflecting the stellar plasma. For life to develop, the host planet must meet two conditions: first one geometric (radius of the orbit) and the second one physics (low density of the solar wind in the extrastellar space traveled by the planet). These two conditions are antithetical because either the planet is close enough to the star (like the sun) to have a surface T allowing the liquid state of the water (but not too close to avoid evaporation) or it is far enough away to have a low-density stellar plasma flux.

The magnetic shield presence, which deflects the particles of the solar plasma, cancels the condition b) and allows the life conditions in the orbital position a) too. The magnetic shield is essential to guarantee the chance of the development of life even where the solar wind would be too intense.

Therefore the correct question is how frequent are the internal planetary structures generating the magnetic field in thermically habitable rocky planets (**Figure 2**), not how frequent are thermally habitable rocky planets.

The subcrustal material of our planet consists of the mantle and the Earth's core, divided into the outer core and the inner core. The mantle is the material immediately below the crust [15]; the rocks constituting this layer have a low intensity of magnetization [15]; therefore the origin of the Earth's magnetic field cannot be explained by the physical characteristics of the mantle.

The source of the main part of the geomagnetic field is even deeper: the core. The thermodynamic conditions of the core exclude the possibility of Weiss domains magnetism as the temperature T is much higher than the T_C of any ferromagnetic crystal.

This part of the geomagnetic field comes from electric currents circulating in the Earth's core, they are linked to the electrodynamic interactions between the outer part of the core and the inner part. The study of the elastic behavior of the interior of the planet indicates transverse seismic waves do not propagate between 2900 and 5000 km of depth from the surface and therefore this layer of the planet is in a liquid state (outer core). Wasilewsky [15], Elsasser [16] and Bullard [17] indicate the contact area between the liquid outer core and the solid inner one to be the self-induction type planetary magnetic generator whose dynamic component is the differential rotation speed Δv between the outer and inner core. This model was perfected by the double dynamo model [18] capable of explaining the phenomenon of geomagnetic field inversions that escaped the Elsasser-Bullard simple dynamo model. How the planet's metallic core was formed is still a matter of debate. If the core was formed by chemical differentiation from the primordial cloud material it is reasonable to suppose that the presence of an important ferrous nucleus is within the planet-genesis norm. The possibility of the formation of the Earth's heavy core is much rarer if the Theia-Earth impact

theory is followed. According to this theory, the impact would have generated the Moon by re-aggregation of the impact materials, mainly giving the Moon the terrestrial crustal material, thus enriching the average composition of the Earth in nuclear material (coming from the heavy nuclear material of the planets Theia and Earth). There are insufficient data to indicate the type of the Earth's core genesis and therefore of its statistical possibility of existence in the other rocky planets (so-called Earth-type). It is therefore impossible, to date, to establish whether the magnetic field of our planet [19] is a singularity or not, but we can propose an evaluation of the general statistics on the star systems of our galaxy based on the observation of the solar system (**Figure 2**).

4. A Metrological Tentative to Define the Planetary Magnetic Fields Statistical Occurrence

Assigning a quantitative value to the component factors of Drake's formula (1), to date, is a conjecture and therefore the reasoning on the possibility of extraterrestrial and galactic life is a speculative one, current studies on this topic have a relevant but qualitative value [20] [21] [22]. The only admissible quantitative statement is that the value of the factors f_p, n_e, f_l, f_i, f_c (probabilistic factors) is

$$0 \le f_p, n_e, f_l, f_i, f_c \le 1 \tag{13}$$

and the parameters R, L (numeric) are integers.

We accept Drake's working hypothesis and try a plausible evaluation of N. Among the many statistical values proposed in the literature we choose:

$R = 7$ stars for year [23].

$f_p = 0.5$ suppose that about half of the stars may have planets.

$n_e = 0.5$ we assign the average value to n_e, remembering however that it could be very low and that

$$\lim_{n_e \to 0} N = 0 \tag{14}$$

$f_l = 0.33$ approximately average value slightly shifted towards negative cases.

$f_i = 0.01$ particularly debated value. The commonly used options range from about 0 (among the billions of living species that have appeared on Earth only very few have become intelligent and only one has survived long enough to develop a technological culture) to about 1 (evolution proposes increasingly complex species therefore reaching the intelligent species is the norm in the evolutionary process of the biosphere). The proposed value is however relatively high.

$f_c = 0.1$ on this parameter there are very controversial indications of a speculative nature, there is no data connected to the f_c's quantization which is random and subjective (the proposed value is among the most widespread in literature).

$L = 10.000$ years about the duration of civilizations. Although history indicates the duration of terrestrial civilizations is less than this value, it must be considered that in the process of succession of the different human civilizations a large part of the technological development of the previous civilization is handed down to the next one. For this reason, technological progress can be considered

approximately linear without considering hypotheses of natural traumatic events for the specie (such as catastrophic biologic crisis (e.g. fatal epidemics), planetary or astronomical cataclysms, …) or artificial (such as nuclear conflicts) that can undermine the existence of the species or critically decrease the number of individuals.

Based on these numerical conjectures Drake formula (1) says

$$N = 7\left[\frac{1}{y}\right]\times 5\times 10^{-1}\times 5\times 10^{-1}\times 3.3\times 10^{-1}\times 1\times 10^{-2}\times 1\times 10^{-1}\times 1\times 10^{4}\left[y\right] = 577.5\times 10^{-2}\cong 6 \tag{15}$$

about six technologically developed civilizations in the Milky Way.

In the same numerical assumption but considering that the others Solar System's rocky planets having much more tenuous magnetospheric field than Earth's [24] [25] [26] [27] we compute the value of n_m of the Solar System:

$$n_m = 1:4 = 2.5\times 10^{-1} \tag{16}$$

from which the result of Drake's formula evolves into

$$w = n_e \times n_m = 5\times 10^{-1}\times 2.5\times 10^{-1} = 1.25\times 10^{-1} \tag{17}$$

from which still

$$N_4 = 7\left[\frac{1}{y}\right]\times 5\times 10^{-1}\times 1.25\times 10^{-1}\times 3.3\times 10^{-1}\times 1\times 10^{-2}\times 1\times 10^{-1}\times 1\times 10^{4}\left[y\right] = 144.375\times 10^{-2}\cong 1 \tag{18}$$

possibility of less than 3 technologically developed civilizations for every 2 galaxies (considering the Milky Way as standard).

So the modified Drake formula (3), using the observational data of the Solar System, indicates that the number N of intelligent civilizations in the Milky Way able to communicate with each other is

$$N \cong 1 \tag{19}$$

the human species.

The fundamental result of the action of the n_m factor (and therefore of w) is not the absolute value of the reduction of N from about 6 (original formula (1)) to about 1 (modified formula (3), (5)) but the relative reduction of the value of N by about 1/6. This considering only the data coming from the observation of the Solar System. The presence of high-energy planetary magnetic fields is a further limit to the likelihood of extraterrestrial life [28]. Notwithstanding that:

- The result of the computation of N, apparently reasonable, derives from absolutely conjectural data and is therefore himself absolutely conjectural.
- The Drake formula remains valid for which it was proposed: the formalization of a method for the prediction of the value of N and not a method for the calculation of N.

5. Conclusion

The geomagnetic field existence in the space around the planet Earth provides

an effective shield against the flow of charged particles of solar origin (solar wind) and against their interplanetary magnetic field IMF. The magnetosphere prevents the flow of subatomic particles from reaching the Earth's surface. Without the geomagnetic field, the surface of the planet would be subjected to a constant and intense flow of solar plasma, even in conditions of Q days. This flow would become very intense in conditions of solar perturbations (D days). Q and D solar wind flow conditions would be a serious obstacle to the stability of the basic organic molecules of life and therefore to life itself and, most likely, also to the lasting survival of a terrestrial type atmosphere and liquid water on the planet's surface. The planet would be sterilized. The probability of intelligent life therefore seems to be linked to the probability of the presence of an Earth-like magnetic field. It is not enough for the rocky planet to orbit in the so-called "liquid water" belt but it is necessary that it has the "Earth-like" electromagnetic shield against the solar wind. In order to take into account the probability that rocky planets possess an Earth-like magnetic field, the n_m parameter has been associated with the n_e one in Drake's formula. To verify the numerical evolution of Drake's formula, the electromagnetic data of the rocky planets of the Solar System are considered (Solar System's n_m). The formula reacts to the insertion of this n_m by decreasing the estimate N from about 6 to about 1 (the human species). The relevant fact is not the absolute decrease in the value of N (which depends on the arbitrary decisions applied to quantize the Drake factors) but the decrease to 1/6 of this numerical result (only taking into account the observational data of the Solar System). The possibility of intelligent life in the Milky Way is lower than that indicated by Drake's original formula. Obviously, Frank Donald Drake's formula keeps intact the value for which it was proposed: to formalize an evaluation process of N and not to comput N.

Conflicts of Interest

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

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