THE LIVING GALAXY

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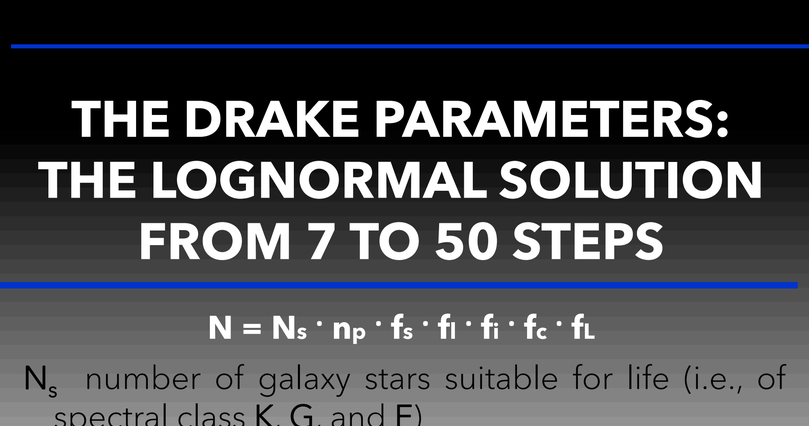
WINNERS AND LOSERS IN THE MILKY WAY

THE DRAKE PARAMETERS: THE LOGNORMAL SOLUTION FROM 7 TO 50 STEPS

$$N = N_s \cdot n_p \cdot f_s \cdot f_l \cdot f_i \cdot f_c \cdot f_L$$

- N_s number of galaxy stars suitable for life (i.e., of spectral class K, G, and F)
- N_p number of planets per star in the habitable zone (of spectral class K, G, and F)
- f_s fraction of stable planets in the habitable zone (function of duration ΔT)
- f_l fraction of suitable planets where life actually develops
- f_I fraction of planets inhabited by intelligent life
- f_c fraction of planets where intelligent life decides to communicate
- f_L fraction of the planet's lifetime in which intelligent life persists compared to the duration of the last stellar population (about 7 Gy)



PART I – ASTRONOMICAL PARAMETERS

1 NUMBER OF GALAXY STARS SUITABLE FOR LIFE (OF SPECTRAL CLASS F, G, K)

2 NUMBER OF SUITABLE PLANETS IN THE HABITABLE ZONE PER STAR (OF SPECTRAL CLASS F, G, K)

3 FRACTION OF STABLE PLANETS
- multiple star systems
- supernovae within 40 ly (light years)
- gamma-ray bursts within 5,000 ly (light years)
- super flares from their own star
- transit of gas giants on inner orbits
- prolonged meteor bombardment
- instability of the rotation axis
- absence of the carbon cycle
- absence of the planetary magnetic field

PART II – BIOLOGICAL PARAMETERS

4 FRACTION OF PLANETS WHERE LIFE ARISES
- the abiological synthesis of biological molecules
- the concentration of the primordial broth
- the formation of lipid bags
- the inclusion of chlorophyll in lipid membranes
- the "proton photopump"
- the formation of nucleic acid filaments
- the catalytic role of RNA
- determination of roles
- formation of the cell membrane
- emergence of the genetic code

5A FRACTION OF PLANETS WHERE EUKARYOTES ARISE
- the evolution of an aerobic bacterium
- the host-symbiont encounter
- the formation of pores and the extrusion of extensions
- the "wrapping" of the symbionts and the disappearance of the cell wall of the host
- the "penetration of the symbionts into the cytoplasm"
- the migration of DNA from the genome of the symbiont to that of the host
- the acquisition of the eukaryotic cytoplasmic membrane
- the incorporation into a single coating and phagocytosis

5B FRACTION OF PLANETS IN WHICH ANIMALS (METZOI) WERE BORN
- the acquisition of a complex life cycle
- the aggregation of zoospores and the formation of the synzoospore
- the sedentary colony composed of differentiated cells
- the production of collagen

5C FRACTION OF PLANETS WHERE TECHNOLOGICAL CIVILIZATIONS (ETCs) ARE BORN
- increase in metazoan size (nervous and vascular system)
- development of limbs
- conquest of the mainland
- differentiation of terrestrial animals
- acquisition of sociality
- upright stance and manual dexterity
- change in diet and brain growth
- organization of the brain for abstract thought
- birth of articulated language and technique

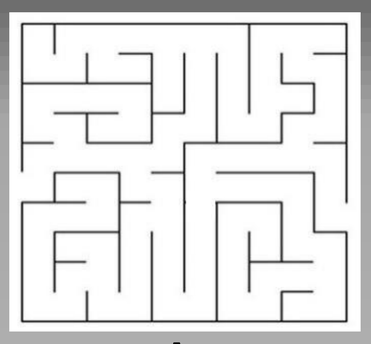
PART III – SOCIAL PARAMETERS

6 FRACTION OF PLANETS WHERE LIFE DECIDES TO COMMUNICATE

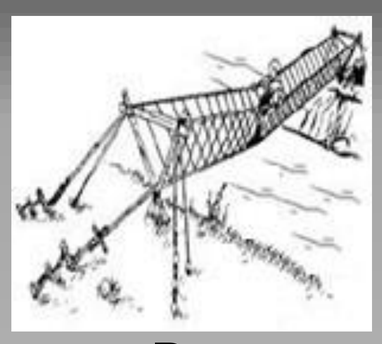
7 FRACTION OF DURATION OF THE ETCs
- self-destruction due to evolutionary insufficiency
- unintentional technological error
- technological insufficiency to face planetary changes
- spontaneous involution
- artificial genetic transition ended on a dead track
- transition of artificial intelligence ended on a dead track
- reaching point Ω

7B ETCs THAT OVERCOME THE 7 CHALLENGES AND BECOME ETERNAL

THE PHASES AND THE CHALLENGES OF 50 STEPS



A

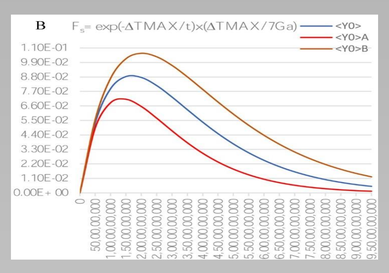


B

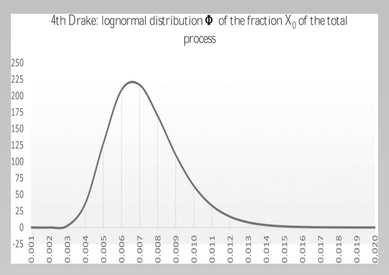
A *phase* $p_A = 1-(1-p_{A0})^n$ increasing with n

B *challenge* $p_B = (p_{B0})^n$ decreasing with n

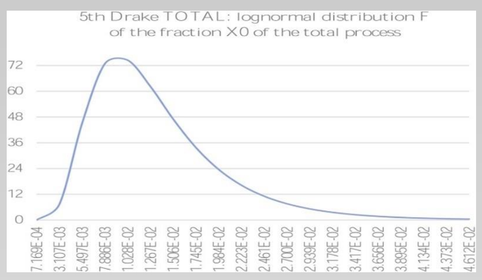
ASTRONOMICAL PARAMETERS 3°



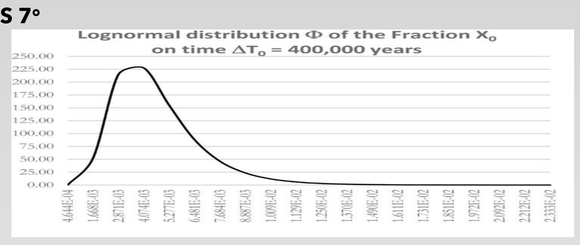
BIOLOGICAL PARAMETERS 4°

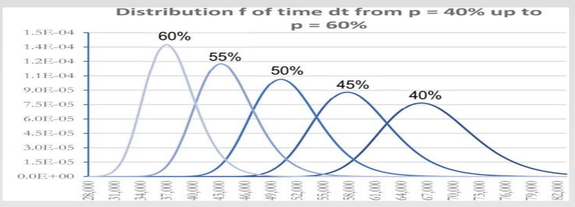


BIOLOGICAL PARAMETERS 5°

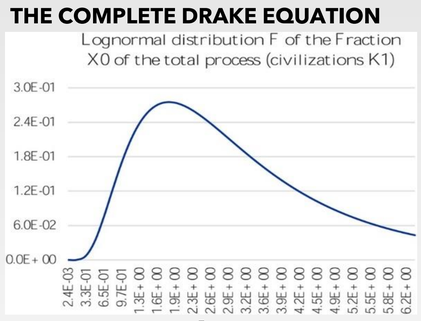


SOCIAL PARAMETERS 7°

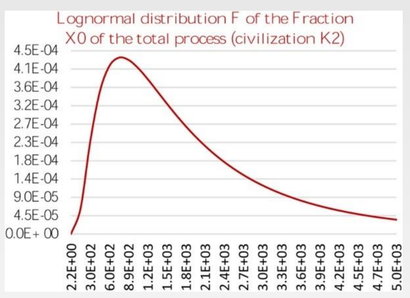




THE COMPLETE DRAKE EQUATION



A



B

A – distribution of static civilizations with **<N>=3.41** and **σ(N)=2.43**

B – distribution of dynamic civilizations with **<N>=2,214** and **σ(N)=2,224**

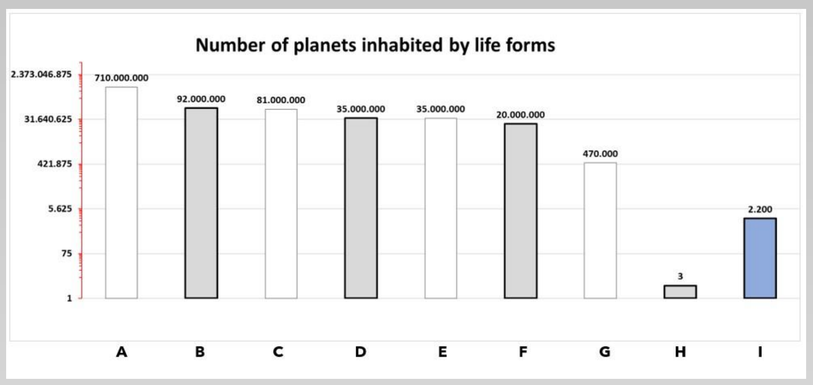
RESULTS AND CONCLUSIONS

development phase	duration	sum
1 - ADEAN	0,80 Gy	0,80 Gy
2 - prokaryotes	**0,10** Gy	**0,90** Gy
3 - GOE	1,60 Gy	2,50 Gy
4 - eukaryotes	**0,50** Gy	**3,00** Gy
5 - NOE	0,50 Gy	3,50 Gy
6 - metazoans	**0,50** Gy	**4,00** Gy
7 - past static ETC	**0,50** Gy	**4,50** Gy
8 - present static ETC	**0,05** Gy	**4,55** Gy
9 – dynamic ETC	**0,40** Gy	**4,95** Gy

Tab. 12 - TOTAL Drake: time scale of a galactic civilization (Earth model)

	planet age Gy)	number of planets hosting or having hosted life	distance (ly)	Total of Suitable planets	distance (ly)
A	0.90	710,000,000 planets where prokaryotes were born in the past	28	1,500,000,000	22
B		92,000,000 planets where prokaryotes are present today	55	190,000,000	43
C	3.00	81,000,000 planets where eukaryotes were born in the past	57	330,000,000	36
D		35,000,000 planets where eukaryotes are present today	76	140,000,000	48
E	4.00	35,000,000 planets where metazoans were born in the past	76	190,000,000	43
F		20,000,000 planets where metazoans are present today	91	110,000,000	52
G	4.50	470,000 planets where ETCs K1 static were born in the past	319	140,000,000	48
H		3 planets where ETCs K1 static are present today	16,515	92,000,000	48
I	4.95	2,200 current planets with ETCs K2 dynamics (eternal)	1,909	92,000,000	48

Tab. PART IV.4 - TOTAL Drake: the population of galactic life and the relative distances from us of both suitable planets and planets suitable and populated in the past and present: a average volume of the galactic disk of **$1.53 \cdot 10^{13}$ ly³** has been hypothesized **(IJA 14/06/2023 Mieli, Valli, Maccone)**



a) In the galaxy, as a primitive K1 civilization (actually less than K1), we are almost alone, with about 3 ETC including us currently present.

b) Approximately one civilization like ours forms every 20,000 years and has a slightly higher than 0.4% chance of not going extinct (1 in 250).

c) There are nearly half a million civilizations like these already extinct in the galaxy.

d) Conversely, in the galaxy, if they overcame the seven challenges of the 7th parameter, there could be about 2,000 super-civilizations, K2 level or almost, which would form one every 5 million years.

e) In this case, these super-civilizations would now be free to move between planetary systems and would likely be within about 50 light-years from us (the distance of the first habitable planets used as intermediate travel stations). The organization and intentions of these super-civilizations are currently unknown to us and could be the subject of further study in our future work. The rest of the galaxy is a jungle of life forms at various stages of development (tens of millions of planets inhabited by living forms).

REFERENCES

This is a transposition of the paper published on 14 June 2023: ***Astrobiology: resolution of the statistical Drake equation by Maccone's lognormal method in 50 steps***, International Journal of Astrobiology - Volume 22 , Issue 4 , August 2023, pp. 428 – 537 - DOI: https://doi.org/10.1017/S1473550423000113 (E. Mieli, A. M. F. Valli, Claudio Maccone). The paper was also published in book format by the Springer publishing house with the title, ***The Living Galaxy*** and ***La Galassia Vivente***