RESEARCH ARTICLE

Some computations on the Drake equation to encapsulate the probable number of broadcasting civilizations

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ABSTRACT

The Drake equation has been utilized to investigate the number of probable civilizations in the Milky Way galaxy by computing the parameters in the equation involved, in a more realistic fashion. The two extreme boundaries have been first determined from the conservative and optimistic point of view and thereby extracting the realistic parameters the probable number of broadcasting civilizations has been estimated. The limitation of the equation is outlined and its suitable modifications have proposed.

Keywords: Milky Way galaxy, Radio sources, Planet

1. Introduction

The Drake equation (http://www.astrodigital.org/astronomy/drake_equation.html) is an attempt to establish the number of intelligent civilizations that existed in the Milky Way galaxy. The equation is composed of seven terms. Out of which the first six are used to compute the rate at which intelligent civilizations are being created and the final term identifies how long each lasts on an average as a broadcasting civilization (Charbonneau *et al*., 2007, Bhattacharya *et al*., 2009, Bhattacharya *et al*., 2010, Bhattacharya *et al*., 2011). It is, however, inapplicable to civilizations in other galaxies as they are too distant to be able to communicate through radio signals successfully. In this paper we have first determined the two extreme values and thereby extracting the realistic parameters the probable number of broadcasting civilizations has been estimated. The limitations of the Drake equation are critically focused and its modifications have suggested.

2. Theoretical considerations

According to Drake equation if the number of broadcasting civilization is denoted by N, then

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

where, R = Average rate of formation of suitable stars (stars/year) in the Milky Way galaxy

n_e = Average number of habitable planets per star

f_p = Fraction of stars that form planets

f_l = Fraction of habitable planets (n_e) where life emerges

f_i = Fraction of habitable planets with life where intelligent may be evolved

f_c = Fraction of planets with intelligent life capable of interstellar communication

L = Years a civilization remains detectable.

Drake used the following values in expression (1) for identifying the number of civilizations:

R = 10, n_e = 2.0, f_p = 0.5, f_l = 1.0, f_i = 0.01, f_c = 0.01, L = 10,000

When all those proposed values were substituted in the equation, the value of N comes out as 10; *i. e.* the number of broadcasting civilizations in our galaxy appears to be 10. As a conservative estimate one may proceed with a belief that suitable planets are rare, life seldom becomes intelligent and intelligent civilizations do not last for a longer period. Under that restricted situation, the following typical values may get priority for computation: R = 5/year, n_e = 0.01, f_p = 0.5, f_l = 0.13, f_i = 0.001, f_c = 0.01 and L = 1000 years, when we get by using Equation (1) N = 0.0000325. The chosen data set obviously concludes that we are almost alone in our galaxy. But for a more positive computed result, if we take, R = 8/year, n_e = 2.0, fp = 0.5, f_l = 0.33, f_i = 0.01, f_c = 0.01 and L = 10,000 years, we get, N = 2.64. The results indicate that only two communicative civilizations exist in our galaxy at any given time, on an average.

Alternatively, if one is more optimistic and assumes that planets are common, life always arises when planets are favorable, 10% of civilizations become willing and able to communicate radio signals, then spread through their local star systems for 100,000 years which is, in fact, a very short period in geological time, we may go through the following computation: R = 10/year, n_e = 2, f_p = 0.5, f_l = 1, f_i = 0.1, f_c = 0.1, and L = 100,000 years, we have, N = 10,000. The optimistic assumption thus indicates that there are quite a good number of civilizations in the galaxy. All the above three results under varying situations prompted us to make a rigorous calculation wherein R, n_e and L values we have changed but f_s, f_l, f_i and f_c are kept unaltered to find the appropriate values of N under changing conditions. In a more realistic manner we prefer to choose: f_p = 0.5, f_l = 1, f_i = 0.01, f_c = 0.01 as fixed values in our computation when the Drake equation can be expressed in a simplified form as,

$$N = 0.00005 * R * n_e * L = k * R * n_e * L, \quad [\text{taking } k = 0.00005] \quad \ldots(2)$$

The computed results obtained by using Equation (2) are summarized in Table 1, which reveal, at a glance, the probable number of broadcasting civilizations with the length of time for which such civilizations release detectable signal in space.

Table 1: Probable number of civilizations (N) for different average rate of formation of suitable stars (R), average number of habitable planets per star (n_e) and years a civilization (L) remains detectable

Set I	R	5	5	10	10	5	5	10	10
	n_e	1	2	1	2	1	2	1	2
	L	500	500	500	500	1000	1000	1000	1000

	N	0.125	0.25	0.25	0.5	0.25	0.5	0.5	1
Set II	*R*	5	5	10	10	5	5	10	10
	n_e	1	2	1	2	1	2	1	2
	L	5000	5000	5000	5000	10000	10000	10000	10000
	N	1.25	2.5	2.5	5	2.5	5	5	10

It appears from the table that if the years a civilization remains detectable are taken as 500 and 1000 for two sets of data, the maximum probable number of civilization becomes 1. On the other hand, if the years a civilization remains detectable be taken as 5,000 and 10,000 for another two sets of data the probable number of civilization becomes always greater than 1 with a maximum to 10.

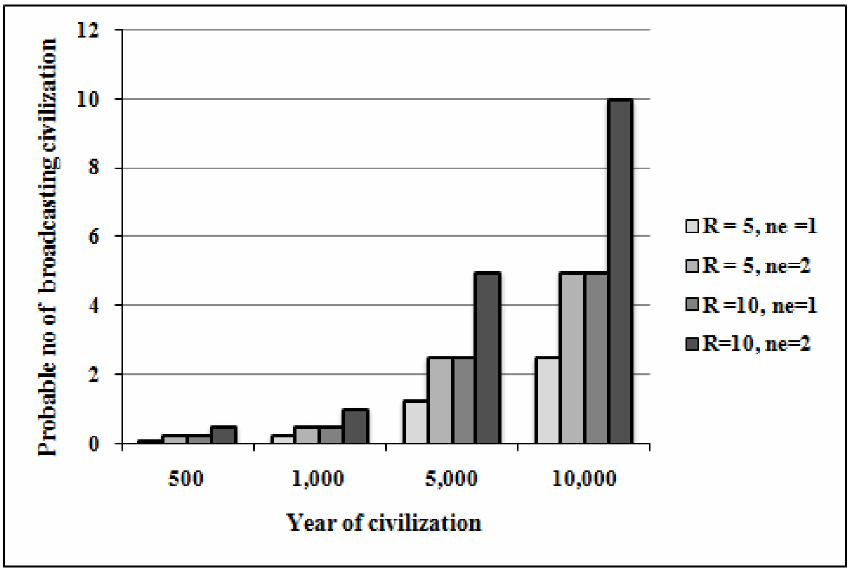

Figure 1: Probable occurrence of broadcasting civilizations with length of time

In Figure 1 we have combined our computed results of probable number of broadcasting civilizations considering year of civilization from 500 to 10,000 for different fixed realistic values of f_s, f_l, f_i and f_c. This estimation suggests that the probable number of civilizations transmitting radio signals may lie between 1 and 10 in the Milky Way Galaxy. As an optimistic and conservative approach if the civilizations transmitting radio signals for a link with other civilizations are taken as 5, then also we can expect successful radio signal reception by applying suitable techniques and instruments.

3. Discussions

The Drake equation is still not a very successful one due to some of the elements in the equation which would take too long to get an accurate sample for providing a scientifically sound explanation. It further appears that the equation should consider other factors of practical importance. As for example, the equation should be multiplied by how many times an intelligent civilization may occur on planets where it has once happened. Even if an intelligent civilization comes to an end of its lifetime, life may still prevail on the planet for billions of years wherefrom the next civilization may be evolved. Hence several civilizations may appear and disappear during the life span of a single planet. If n_r be the average number of time a new civilization may reappear on the same planet where an early civilization has once appeared and ended, then the total number of civilization in that planet would be $(1+ n_r)$, which is the actual reappearance factor and should be included in the Drake equation. However, it should be mentioned that the factor n_r depends on the cause of civilization extinction. In case of temporary uninhabitability like a nuclear winter, n_r should be relatively high but for permanent uninhabitability like stellar evolution, n_r may be almost zero. In fact, the Drake equation has many uncertainties in its parameters. Also identifying and categorizing the relevant parameters is the most fundamental task for the proper utilization of the equation and thereby to exploit the search for extraterrestrial intelligence and the likelihood of its existence (Reines and Marcy 2002, Luhman *et al.,* 2005, Elliott 2007). It should be pointed out that radio propagation in GHz frequency is largely by attenuation due to precipitation and so a successful reception of any signal in microwave band there is a need of a strong database (Sarkar and Kumar 2007, Bhattacharya *et al*., 2011).

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