ON THE IMPORTANCE OF SETI FOR TRANSHUMANISM

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Abstract. It is argued that astrobiology in general, and the search for extraterrestrial intelligence in particular, are of foremost importance for the transhumanist endeavor. It is sketched how one can show incompleteness, at best, of the arguments usually cited in support of the uniqueness of human intelligence in the Galactic context. In addition to the arguments conventionally cited in support of SETI, and which can be easily cast in the form in which their significance for the future of humanity is manifest, a specific class of phase-transition models of development of complex life and intelligence, suggests another powerful motivation: a very practical issue of strategic information in the great strife for creating values out of the Galactic material resources.

> If grey-eyed Athena loved you
> the way she did Odysseus in the old days
> in Troy country, where we all went through so much...
>
> *The Odyssey*, Homer, cca. 800 BC
> (Nestor to Telemachos)

1. Introduction

It is hard to deny that the Search for ExtraTerrestrial Intelligence (SETI; for a recent review, see Tarter 2001) is one of the major scientific adventures in the history of humankind. At the beginning of twenty-first century it remains one of the oldest and most fascinating scientific pursuits. However, SETI is just a small part of the larger field of astrobiology, the field that is currently in the epoch of explosive development (see beautiful recent reviews of Des Marais and Walter 1999; Darling 2001; Ehrenfreund et al. 2002).[1] A host of important discoveries have been made during the last decade or so, the most important certainly being a large number of extrasolar planets, but also the existence of many extremophile organisms possibly comprising “deep hot biosphere” of Thomas Gold; the discovery of subsurface water on Mars and the huge ocean on Europa, and possibly also Ganymede and Callisto; the unequivocal discovery of amino-acids and other complex organic compounds in meteorites; modeling organic chemistry in Titan’s atmosphere; the quantitative treatment of the Galactic habitable zone (Gonzalez et al. 2001); the development of a new generation of panspermia theories (e.g. Raulin-Cerceau, Maurel, and Schneider 1998), spurred by experimental verification that even terrestrial microorganisms easily survive conditions of an asteroidal or a cometary impact; etc. But the role of astrobiology does not end here; in the nice phrase of Des Marais and Walter (1999), “recent discoveries create a mandate”. The same authors continue:

> Operationally, astrobiology integrates key research disciplines into a program that combines technology development, remote observation (space missions), model building, and the extensive involvement of educators and the public. This agenda addresses the following three canonical questions: How does life begin and develop?

> Does life exist elsewhere in the universe? What is the future of life on Earth and in space?... Astrobiology strengthens linkages between science, technology, and the humanities, creating an integrated view of our world that will be beneficial for helping to define the roles that future generations will play as stewards of our global environment and its resources.

It would be natural to expect that transhumanism, defined for instance as "[t]he study of the ramifications, promises and potential dangers of the use of science, technology, creativity, and other means to overcome fundamental human limitations," (http://www.transhumanism.org/resources/faq.html) will foster a multifold interest in astrobiology. (The discussion and conclusions of the present study apply even if we relax—as some transhumanist thinkers deem appropriate—the qualification of "human" in order to encompass any form of Earth-originating complex lifeforms.) The third "canonical" astrobiological question pertains, obviously, to transhumanist issues, but that is just the beginning of the story. Only in comparison to other, possible or actual, life forms do we understand and may hope to overcome our "fundamental limitations." One of the basic lessons of astrobiological research is that all species are condemned to become extinct due to the astrophysical or geophysical processes (like the cometary/asteroidal impacts or supervolcanism), if not for other reasons (typically on smaller timescales[2]). On the other hand, astrobiology also offers prospects of saving the threatened lifeforms by discovering and investigating other plausible habitats in the universe; in fact, if panspermia hypotheses are correct, this has already happened many times over the course of Galactic history. In its SETI sector, astrobiology offers hope of glimpsing possible future courses of intelligent civilizations, and obtaining the knowledge necessary for survival on vastly larger spatial and temporal scales than usually considered (Dick 2003; more on that below). In short, the mandate of astrobiology seems, at first glance, to be the scientific basis of precisely the transhumanist endeavor.

Curiously enough, some transhumanists seem to share the view, previously regarded as the exclusive playground of religious (notably Christian) fundamentalists, that intelligent life on Earth is unique, at least in the Galactic context.[3] Consequently, they reject any interest in astrobiological and SETI questions, even in the contexts in which it directly (and possibly adversely) influences some of the basic tenets of transhumanism. This strain of thought is expressed particularly well, for instance, in an otherwise brilliant paper on existential risks humanity faces (Bostrom 2001):

> The probability of running into aliens any time soon appears to be very small... If things go well, however, and we develop into an intergalactic civilization, we may well one day in the distant future encounter aliens. If they were hostile and if (for some unknown reason) they had significantly better technology than we will have then, they may begin the process of conquering us. Alternatively, if they trigger a phase transition of the vacuum through their high-energy physics experiments (see the Bangs section) we may one day face the consequences. Because the spatial extent of our civilization at that stage would likely be very large, the conquest or destruction would take relatively long to complete, making this scenario a whimper rather than a bang. ...
>
> There must be (at least) one Great Filter – an evolutionary step that is extremely improbable – somewhere on the line between Earth-like planet and colonizing-in-detectable-ways civilization [64]. If the Great Filter isn't in our past, we must fear it in our (near) future. Maybe nearly every civilization that develops a certain level of technology causes its own extinction.
>
> Luckily, what we know about our evolutionary past is consistent with the hypothesis that the Great Filter is behind us. ... This would change dramatically if we discovered traces of life (whether extinct or not) on other planets. Such a discovery

> would be bad news. Finding a relatively advanced life-form (multicellular organisms) would be especially depressing.

Thus, we are led into a bizarre situation that out of all scientific disciplines, astrobiology is the only one whose successes are *not* desirable. This particularly applies to the SETI sector of the astrobiological endeavor. To other complaints against the SETI enterprise, one is tempted to add another: psychological welfare of humanity, namely the need to avoid being “depressed”!

This reasoning is based on an important paper of Hanson (1998), who introduced the term “Great Filter”. Hanson presents a ladder of steps leading from dead matter to a universe of intelligent life colonizing the universe. These steps include physico-chemical, biological, and socio-technological phenomena. With absence of any manifestations of advanced intelligent life elsewhere in the universe, we have to conclude that somewhere along the ladder we have a “filter”, i.e. one or more steps which are very improbable. In Hanson’s words, “someone’s story is wrong”, meaning that the filter falls within the domain of at least one particular science whose predictions are wrong when compared to the naive expectations. While not completely skeptical as far as existence of extraterrestrial civilizations is concerned, Hanson’s paper still has at least three problematic features. The first (which does not concern us here) is the unwarranted assumption that most intelligent species will tend to expand and colonize throughout the Milky Way. The second is the missing discourse on the risks inherent in our astrobiological position (which we shall discuss in some detail below). Notably, Hanson seems to almost entirely ignore numerous physical factors which that can terminate or limit the growth of life *after* it has already started. The third and the most important problematic feature of Hanson’s article is that it introduces a “see-saw” tension between the optimism for future of human life and the optimism for life in general cosmic context:

> Together these plausible explanations have persuaded countless teams to construct relatively high estimates of the probability that any one planet will eventually produce intelligent life such as ourselves, by estimating relatively low values for each filter term in the famous "Drake Equation".
>
> Similarly, technological "optimists" have taken standard economic trends and our standard understanding of evolutionary processes to argue the plausibility of the story I gave above, that our descendants have a decent chance of colonizing our solar system and then, with increasingly fast and reliable technologies of space travel, colonizing other stars and galaxies. If so, our descendants have a foreseeable chance of reaching such an explosive point within a cosmologically short time (say a million years)...
>
> While all of these stories are at least minimally plausible, our main data point implies that at least one of these plausible stories is wrong -- one or more of these steps is much more improbable than it otherwise looks. If it is one of our past steps, such as the development of single-cell life, then we shouldn't expect to see such independently evolved life anywhere within billions of light years from us. But if it is a step between here and a choice to explode that is very improbable, we should fear for our future. At the very least, our potential would have to be much less than it seems. Optimism (as defined here) regarding our future is directly pitted against optimism regarding the ease of previous evolutionary steps. To the extent those successes were easy, our future failure to explode is almost certain.

As a consequence of such a wide-sweeping assertion, the predominant atmosphere of technological optimism in transhumanist (and generally educated) circles turns easily into indifference or hostility toward SETI and related activities.[4]

Fortunately, the situation is not necessarily so simple. In the remainer of this paper, we shall argue that the issue of existence and properties of extraterrestrial intelligence, as well as its impact on the future human development, should be taken very seriously into account in any analysis of the future of humanity. Scepticism expressed by Bostrom is almost unwarranted even today, when the astrobiological adventure is at its very beginning. For instance, even the "rare Earth" hypothesis of Ward and Brownlee (2000), which many researchers regard as being itself rather extreme, does state that simple bacterial life is ubiquitous throughout the Galaxy, while suggesting (the controversial part!) that complex metazoans are indeed very rare in the Galaxy. The advances of biochemistry and molecular biology (which are beginning to be visible everywhere, from bathroom supplies to the stock market) cannot fail to suggest that we are getting closer to the understanding of the origin and underlying mechanisms of life in a completely naturalistic manner. Similarly, various version of computationalism ("strong AI", "functionalism," etc.) are suggesting to us that origin and underlying mechanisms of thought and intelligence itself are eventually to be understood in a similar naturalistic manner. SETI-scepticism amounts to the thesis—probably unique in the entire history of science—that a completely natural phenomenon occured only once in a vast region of space and time, while it could *prima facie* occur billions of times.[5]

2. The arguments against ETI are incomplete/wrong

The idea of uniqueness of Earth and intelligence rests on two arguments most frequently cited in this respect:

(1) Tsiolkovsky-Fermi-Viewing-Hart-Tipler's question[6] "Where are they?" in its modern von-Neumann-probe rendering,

and

(2) Carter's "anthropic" argument.

Tsiolkovsky, Fermi, Hart, and their supporters argue on the basis of two premises: the absence of extraterrestrials on Earth and in the Solar System, and the fact that they have, *ceteris paribus*, more than enough time in the history of Galaxy to visit, either in person or through their self-replicating probes. Characteristic time for colonization of the Galaxy, according to these investigators, is $10^6 – 10^8$ years, making the fact that the Solar System is (obviously) not colonized hard to explain, if not for the absence of extraterrestrial cultures. On the other hand, Carter's "anthropic" argument ("argument from ignorance" would be a better label here) tries to infer conclusions from the possible relationships between the alleged astrophysical (τ_*) and biological (τ_l) timescales. In the Solar system, $\tau_* \approx \tau_l$, within the factor of two. However, in general, it should be either $\tau_l >> \tau_*$ or $\tau_* >> \tau_l$ for two uncorrelated numbers. In the latter case, however, it is difficult to understand why the very first inhabited planetary system (that is, the Solar System) exhibits $\tau_* \approx \tau_l$ behaviour, since we would then expect that life (and intelligence) arose on Earth, and probably at other places in the Solar System, much earlier than they in fact did. This gives us probabilistic reason to believe that $\tau_l >> \tau_*$ (in which case the anthropic selection effects explain very well why we do perceive the $\tau_* \approx \tau_l$ case in the Solar

System). Thus, according to Carter, extraterrestrial life and intelligence have to be very rare, which is the reason why we have not observed them so far.

Both (1) and (2) are at best inconclusive, and at worst plain wrong. While a detailed refutation is by far beyond the aims and scope of the present paper, we shall give only a few hints, directing the interested reader to the cited literature. First, the colonization timescale is still largely uncertain; for instance, diffusion models of Newman and Sagan (1981) give the relevant timescale as $\sim 10^9$ years, which would correspond to the naive answer one might give on the Fermi's question: *They are still on the way*! Second, the issue of motivation of colonizers, and particularly their von Neumann probes is much less clear and unambiguous than the "contact pessimists" would have us believe. Notably, as suggested by Brin (1983) in his seminal review, the "deadly probes" scenario (the idea that the dominant behavior of self-replicating probes is destruction of nascent civilizations, not colonizing) is one of just a few theoretically satisfactory explanations of the "Great Silence". In a similar vein, Kinouchi (2001) has recently argued that the phenomenon of persistence, well-known from statistical physics, holds the key for explanation of the apparent absence of extraterrestrial civilizations; in this picture, Galactic colonization by advanced ETIs could have already last for quite some time without influencing the Solar System. Wilson (1994) has persuasively criticized Carter's usage of the anthropic principle to show that life is rare in the universe.

But the most important line of thought which can easily defeat both Fermi-Hart-Tipler's and Carter's arguments lies in investigation of hidden temporal assumptions in these arguments. Fermi et al. suppose that the history of the Galaxy is uniformitarian, in the sense that advanced technological communities could arise at any point in the Galactic history. The exception would be, perhaps, the first couple of billion years, when the metallicity was too low. The seminal breakthrough of Lineweaver (2001) enables us to calculate for the first time an age distribution for terrestrial planets, which is not uniform in time but reaches a peak at the age of 6.4 ± 0.9 Gyr; in other words, an average terrestrial planet in the Milky Way is almost two billion years older than Earth! This already hints at what we wish to elaborate below: that simplistic uniformitarianism is unwarranted in astrobiology. Similarly, Carter assumes that the only relevant astrophysical timescale is the Main Sequence stellar lifetime. Uniformitarianism has not shown brightly in astrophysics and cosmology, at least since the demise of the classical steady-state theory in the mid-1960s (Kragh 1996). Today we are quite certain that evolutionary properties of astrophysical systems are from time to time guided by processes either unique (like the primordial nucleosynthesis or the reionization of intergalactic medium[7]), or occuring at timescales so much vaster than the timescales of human civilization that the probability of actually observing them is nil (like the recently computed evolution of M-dwarf stars[8]). In the specific case, if the phase-transition model sketched in a brilliant short paper of Annis (1999; see also Clarke 1981) is correct—as we have more and more reasons to believe—the relevant timescale is the one describing intervals between major Galactic-wide catastrophes, *precluding* the complexification of planetary biospheres and, consequently, the development of intelligent observers. There are several plausible candidates for this *global regulation mechanism*. The strongest, as suggested by Annis in his ingenuous study, are gamma-ray bursts (henceforth GRBs), which accompany either a coalescence of binary neutron stars or explosions of super-massive stars, also known as the *hypernovae* (for a review of GRB mechanisms, see Piran 2000).

Astrobiological effects of GRBs have been investigated recently in a number of papers (Thorsett 1995; Dar 1997; Scalo and Wheeler 2002), and much of the older literature dealing with effects of supernova explosions is useful in this case too (after scaling, of course; see, for instance, Tucker and Terry 1968; Ruderman 1974; Clark, McCrea, and Stephenson 1977). It seems that each GRB is surrounded by a "lethality zone" in which its effects are deadly for complex lifeforms (eukaryotes); according to Scalo and Wheeler (2002). The radius of this zone is ~14 kpc, rather large in comparison to the Galactic habitable zone. The exact effects of a GRB within a "lethality zone" are still somewhat controversial, but it is clear that there will be at least two deadly effects capable of causing mass extinctions: 1. creation of nitrogen-oxides (usually denoted by NO_x) in the upper atmosphere, which will destroy the ozone layer for thousands of years, thus enormously increasing UV radiation at planetary surface; and 2. creation of a longer delayed pulse of cosmic rays, which penetrate the atmosphere (and even rocks and soil up to several km of depth) and cause various sorts of damage to biological materials. Both these effects are prolonged in comparison to the GRB itself, thus affecting not only the hemisphere directed toward the source. In fact, the consequences in biological domain may last many generations, especially when one considers such effects as increase in frequency of cancers, and occasionally very long interval needed for a species to die out when its population decreases below the so-called minimum viable population (for a popular account, see Raup 1991).[9]

Other suggested regulation mechanisms are the climatic change due to interaction with Galactic spiral arms (Shaviv 2002), neutrino-induced extinctions (Collar 1996), or Galactic tides leading to the Oort comet cloud perturbations (e.g. Clube and Napier 1990; Rampino 1998).[10] Their common property is that they are *global*, i.e. influencing the entire Galactic habitable zone, or a large portion of it. GRB-regulation, however, has another desirable property: quantifiable *secular evolution*, which explains our own existence at this particular epoch of the Galactic history. Notably, cosmology suggests the rate of GRBs behaves, on the average, as $\propto \exp(-t/\tau)$, with the time-constant τ of the order of 10^9 yrs (Annis 1999). As noticed by Norris (2000), we have to ensure that there is no "overkill" as far as the regulation mechanisms are concerned, and that our own existence is explicable—and not fantastically improbable!—in naturalistic terms. This is readily achieved within the framework of the GRB-dominated phase-transition picture: cosmology assures us that the average rate of GRBs increases with redshift, i.e. decreases with cosmic time. When the rate of catastrophic events is high, there is a sort of quasi-equilibrium state between the natural tendency of life to spread and complexify, and the rate of destruction and extinctions governed by the regulation mechanism(s). When the rate becomes lower than some threshold value, intelligent and space-faring species can arise in the interval between the two GRB-induced extinctions, and the Galaxy experiences a phase transition: from essentially dead place, with pockets of low-complexity life restricted to planetary surfaces, it will, on a very short Fermi-Hart-Tipler timescale, become filled with high-complexity life. We are living within that interval of exciting time, in the state of *disequilibrium* (Almár 1992), on the verge of the Galactic phase transition.[11]

It is clear that this class of models effectively removes the threat to ETIs from both Fermi-Hart-Tipler and Carter's arguments. Elsewhere in the Galaxy there are other planets with the level of complexity achieved more or less similar to the terrestrial one. At each of them, a Fermi can ask his question, but that will not remove the others from existence. There simply was not enough time for them to come to us, since the astrobiological history—as far as complex metazoans are concerned—is different and significantly shorter from the history of dark matter, stars, and gas clouds which constitute the physical structure of the Galaxy. Local astrobiological clocks can tick at various rates, but they are all from time to time reset by the global regulation mechanism(s). But Fermi's question is *rapidly becoming pertinent*, when we realize that during the phase transition many advanced intelligent societies are bound to develop, but they are not all bound to expand to their utmost limits (that is, to colonize the Galaxy) within the same interval of time. We shall return to this important point later.

On the other hand, the very existence of well-defined astrophysical and biological timescales is an unwarranted assumption of Carter's argument. This assumption is wrong in the context of the phase-transition models. The real timescales are specific to each planetary system, depending on such factors as the location of the system in the Galactic habitable zone (GRB distribution having a spatial, as well as temporal aspect!), peculiarities of the local environment (notably the density and distribution of cometary/asteroidal material presenting the impact hazard or quantity of radiogenic isotopes driving plate tectonics and associated carbon recycling), and—of crucial importance—the epoch of Galactic history. In other words, there is no physical reason why on planet A, at galactocentric distance R_A and at epoch t_A we could not have $\tau_l >> \tau_*$ while on planet B (characterized by R_B, t_B, and probably some other astrobiological parameters) we could have $\tau_l << \tau_*$. The dependence on the epoch is particularly important; to paraphrase the title of the controversial book by Ward and Brownlee (2000), *Earths might be rare in time, not in space*. This sort of models can also shed some new light on the Drake equation (Walker and Ćirković 2003; Ćirković 2003). In other words—and to paraphrase Homer's "old Nestor"—it is easy enough to be wise (intelligent) at this epoch of Galactic history, in contrast to the previous eras!

3. SETI and transhumanism

If we admit insufficiency of arguments against the existence of ETI (which, of course, does not mean that the arguments for ETI are very strong—just that the case is completely open!), we may ask for specification of possible important issues and benefits of SETI projects from the transhumanist vantage point. We shall consider three major source of relevance (and indeed importance) of the SETI endeavor for transhumanism in some detail. The first two are rather straightforward, to which the third one, stemming from the very physics of phase-transition models is added.

3.1. Classical benefits of Drake et al.

In the period of "contact optimism" in 1960s and 1970s several beneficial aspects of SETI projects have been listed by pioneers such as Frank Drake, Carl Sagan, Ronald Bracewell, and others (e.g., Bracewell 1975). It was pointed out that SETI projects are cheap and efficient, offering a wealth of ETI-unrelated scientific data, enabling testing of astronomical (especially radioastronomical) equipment, and serving an important educational role. In addition, through a unique blend of multidisciplinarity and public interest, SETI offers an excellent avenue of communicating general scientific knowledge to the lay public; Carl Sagan's work on astronomy public outreach is perhaps the most splendid example of what can be done in this respect. Stock examples also include such difficult to quantify or intangible benefits as the sense of unity of humankind when faced with the vastness of space and the potential alien diversity.

There is no need to dwell here longer on these issues, since they stand the same today as when they were suggested. Subsequent development has only strengthened some aspects of them: notably optical, IR, and other SETI projects have widened the horizons for collateral scientific benefits, and the unity of humankind certainly seems more desirable than ever.

3.2. The knowledge that it is possible to pass the "Great Filter"

Although the anthropic argument of Carter has less force than is usually assumed, this is not tantamount to stating that the anthropic reasoning cannot teach us important lessons about our relationship to the physical universe. Quite the contrary: the central problem of SETI studies can be expressed, as in Hanson (1998), as the question "Where are we along the 'Great Filter'?" It is overoptimistic to state that it is behind us, and it is overpessimistic to claim that we are at its beginning. There are important reasons to believe that we are, in fact, somewhere in between, because while we have overcome a lot of possible existential threats in the last couple of Gyrs, some of them still threaten us. Notably, the threats of a global nuclear, biotechnological or nanotechnological cataclysm, either as a consequence of intentional or accidental misuse of these powerful technologies still looms large. To these risks, rather publicized in recent years, one can add other, less certain, but potentially devastating scenarios like the abuse of AI or the artificially triggered vacuum phase transition (the excellent catalogue is Bostrom 2001). This spectrum of existential risks makes some people pessimistic about our future prospects (that is the case for instance, with Stephen Hawking, whose August 2001 interview in "Daily Telegraph" provoked such an attention worldwide). Stock answer to Fermi's question for several decades—especially during the Cold War—was exactly that: *they did not get here, because they have destroyed themselves upon the discovery of nuclear weapons*. (Today one can substitute one's favorite doomsday technology.) Pessimism often bears fatalism and even irresponsibility (thus, only seemingly paradoxically, increasing the chances of disaster).

The best antidote for such existential pessimism would be a discovery of an advanced ETI society or an equivalent entity.[12] The technical means used by such society would already give us some idea which technologies such ETIs use—without destroying themselves. But even without any detailed information, the very fact that SETI succeeded will give us essential information that it is possible to pass the "Great Filter". On the other hand, if one does not engage in SETI, one cannot expect success; at least until it is too late, and here we come to the most important issue in the catalogue of SETI benefits.

3.3. Know thy (potential) rival!

To these rather well-known and publicized benefits of SETI, we should now add another, which has not actually been investigated, at least not outside the SF circles. The main lesson of the phase-transition models is that, starting with some epoch relatively close in our past, the entire Galaxy is open to colonization and technologization by *whoever happens to be there*, or whoever has a very slight—in astronomical terms—advantage. Obviously, the main purpose of colonization of the Galaxy is to use the Galactic physical resources to create new lives, new observer-moments, and ultimately new values. Of course, any detailed analysis of this process hinges on what could be called "interstellar political economy", and in particular the risk/benefit analysis of the interstellar travel and colonization. For the purposes of this cursory study we employ only those assumptions which are advanced by "contact pessimists" in their formulation of Fermi's paradox: that interstellar travel is physically feasible, and at least a finite fraction of all civilizations will engage in it.

The period of phase transition is like a race, when after the starting pistol goes off, many runners strive to reach the same goal. Add to this an amount of variability of initial conditions (runners which would not start exactly from the same starting line), as well as inherent variability (intrinsic differences between the ETI societies), as well as possibility of negotiations, conflicts, and cooperation. In any of these cases, we can hardly escape to conclude that any knowledge on our rival civilizations[13] gathered through SETI is an invaluable resource. This aspect of SETI can be, very loosely, understood as a new form of (literally) intelligence gathering.[14]

This certainly and definitely does not mean that the striving for mastery of resources on the Galactic scale should be conceived like the ruthless grab for material power analogous to the battle of European powers for colonies in eighteenth and nineteenth century, or inhuman brutality accompanying the present-day fight of Western powers for oil reserves of Middle East and Asia. It might have such a dimension—and the considerations of existential risk in Bostrom's sense is applicable here—but it also can be thought as striving for excellence and creativity in undertaking this colossal endeavor. This can be regarded as arguably the most natural extension of the cultural evolution on which so much within the SETI field depends (Dick 2003).

We perceive—especially forcefully in this light—why Bostrom's lackluster treatment of possible catastrophic contact with aliens is unsatisfactory. In some other circumstances and contexts this would not be disturbing at all; but in the context of debates on existential risks no loose end ought to remain.

(Arguably, phase-transition models offer more scope for optimism as far as creation of values is concerned than most of the explanations of the "Great Silence." It suggests that the material resources of the Galaxy simply cannot fail to be converted into values on rather small, in astronomical terms, timescales of the future, no matter what we, humans, decide to do. On the other hand, this sort of optimism may sound bleak to transhumanists, since it offers no warranty as far as the fate of humanity is concerned, in contradistinction to pseudo-religious eschatologies, like the (in)famous Omega-point theory of Frank Tipler. However, this is still more than science usually offers, again in contrast to religion. To some, it still may sound consoling that even if stupidity and irrationality triumph here, on Earth, and we destroy or cripple ourselves, the Galaxy will still be enriched with life, intelligence, and values.)

4. Conclusions

We conclude that skepticism regarding SETI is at best unfounded and at worst can seriously damage the long-term prospects of humanity. If ETIs exist, no matter whether friendly or adversarial (or even beyond such simple distinctions), they are relevant for our future. To neglect this is contrary to the basic tenets of transhumanism. To appreciate this, it is only sufficient to imagine the consequences of SETI success for any aspect of transhumanist interests; and then to affirm that such a success can only be achieved without trying if *they come to us*, which would obviously mean that we are hopelessly lagging in the race for Galactic colonization.

We find a streak of very subtle anthropocentrism hidden in the usual understanding of the "Great Filter" (as expressed by Hanson's quote above). Seemingly, we are led into a dilemma: *either* we are optimists about extraterrestrial life and SETI *or* we are optimists about our particular (human/posthuman) future. We find the dilemma false and a bit hypocritical, like all man-as-the-measure-of-all-things argument from

Protagoras to this day. We *can* have both of the alternatives above; we *can* be optimists about life and intelligence *in general*. And only future astrobiological research can persuasively show to which degree our optimism in both directions is justified.

As all who have ever tackled this question agree, investments in SETI are invariably a minuscule fraction of any civilization's scientific investments. Even the cost of the most ambitious SETI projects imagined so far (like CYCLOPS; see Oliver 1973) is negligible in comparison to such endeavors generally regarded as desirable and worthwhile like the development of artificial intelligence, setting up efficient defense against impacts, or building O'Neill colonies (not to mention more ambitious projects, like terraforming or uplifting of stellar matter[15]). Thus, there is no real economic excuse for neglecting this field, as well as the general astrobiological enterprise, once prejudices and fallacious arguments are rejected. At least this argument applies as long as it is really necessary to influence public opinion at large to support this type of scientific research; it is to be hoped that in future rich societies such research could be performed by individuals even if the majority still continues to consider them irrelevant or even undesirable.

Of course, all this pertains to a long-term view. No theoretical model can guarantee the success of SETI on short timescales, certainly not on the scale of a present-day human lifetime. But, a healthy admixture of long-term views and long-term planning seems inescapable if we wish to leave to our descendants a prospect of living under billion suns of the Milky Way.

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References

Almár, I. 1992, "Analogies between Olbers' paradox and the Fermi paradox," *Acta Astronautica* **26**, 253-256.

Annis, J. 1999, "An Astrophysical Explanation for the Great Silence," *J. Brit. Interplan. Soc.* **52**, 19 (preprint astro-ph/9901322).

Bostrom, N. 2001, "Existential Risks," Journal of Evolution and Technology, vol. **9** (online journal at http://www.jetpress.org/index.html).

Bostrom, N. 2002, *Anthropic Bias: Observation Selection Effects in Science and Philosophy* (Routledge, New York).

Boyce, C. 1979, *Extraterrestrial Encounter: A Personal Perspective* (David & Charles, Newton Abbot, UK).

Bracewell, R. N. 1975, *The Galactic Club: Intelligent Life in Outer Space* (W. H. Freeman, San Francisco).

Bradbury, R. J. 2001, "Matrioshka brains," preprint at http://www.aeiveos.com/~bradbury/MatrioshkaBrains/MatrioshkaBrains.html.

Brecher, K. 1997, "Did A Galactic Gamma-Ray Burst Kill the Dinosaurs?" *Bull. Am. Astron. Soc.* **29**, 1400.

Brin, G. D. 1983, “The ‘Great Silence’: the Controversy Concerning Extraterrestrial Intelligence,” *Q. Jl. R. astr. Soc.* **24**, 283-309.
Cathcart, R. B. 1991, “Macro-engineering and terraforming: building modernized and additional functional regions,” *Spec. Sci. Tech.* **14**, 34-40.
Clark, D. H., McCrea, W. H., and Stephenson, F. R. 1977, “Frequency of nearby supernovae and climatic and biological catastrophes,” *Nature* **265**, 318-319.
Clarke, J. N. 1981, “Extraterrestrial Intelligence and Galactic Nuclear Activity,” *Icarus* **46**, 94-96.
Clube, S. V. M. 1978, “Does our galaxy have a violent history?” *Vistas in Astronomy* **22**, 77-118.
Clube, S. V. M. and Napier, W. M. 1990, *The Cosmic Winter* (Basil Blackwell Ltd, Oxford).
Collar, J. I. 1996, “Biological Effects of Stellar Collapse Neutrinos,” *Phys. Rev. Lett.* **76**, 999-1002.
Criswell, D. 1985, “Solar system industrialization: Implications for interstellar migration,” in *Interstellar Migration and the Human Experience*, ed. by B. Finney and E. Jones (University of California Press), 50-87.
Ćirković, M. M. 2003, “On the Temporal Aspect of the Drake Equation and SETI,” *Icarus*, submitted.
Ćirković, M. M. and Dragićević, I. 2003, “How to undermine Carter’s ‘anthropic’ argument,” in preparation.
Dar, A. 1997, “Life Extinctions by Neutron Star Mergers,” in *Very High Energy Phenomena in the Universe; Morion Workshop*, ed. by Y. Giraud-Heraud and J. Tran Thanh Van (Editions Frontieres, Paris), 379.
Darling, D. 2001, *Life Everywhere* (Basic Books, New York).
Des Marais, D. J. and Walter, M. R. 1999, “Astrobiology: Exploring the Origins, Evolution, and Distribution of Life in the Universe,” *Annu. Rev. Ecol. Syst.* **30**, 397-420.
Dick, S. J. 2003, “Cultural Evolution, the Postbiological Universe and SETI,” *Int. J. Astrobiology* **2**, 65-74.
Dodelson, S. 2003, *Modern Cosmology* (Academic Press, London).
Ehrenfreund, P. et al. 2002, “Astrophysical and astrochemical insights into the origin of life,” *Rep. Prog. Phys.* **65**, 1427-1487.
Fogg, M. J. 1995, *Terraforming: Engineering Planetary Environments* (SAE International, Warrendale).
Freitas, R. A. 1999, *Xenology* (preprint at http://www.aeiveos.com/~bradbury/ETI/Authors/Freitas-RA/Xenology/).
Gonzalez, G., Brownlee, D., and Ward, P. 2001, “The Galactic Habitable Zone: Galactic Chemical Evolution,” *Icarus* **152**, 185-200.
Hart, M. H. 1975, “An explanation for the absence of extraterrestrials on Earth,” *Q. Jl. R. astr. Soc.* **16**, 128-135.
Hanson, R. 1999, “Great Filter,” (preprint at http://hanson.berkeley.edu/greatfilter.html).
Jones, E. M. 1985, “’Where Is Everybody?’ An Account of Fermi's Question,” Los Alamos preprint, at http://lib-www.lanl.gov/la-pubs/00318938.pdf.
Kinouchi, O. 2001, “Persistence solves Fermi paradox but challenges SETI projects,” preprint cond-mat/0112137.
Kragh, H. 1996, *Cosmology and Controversy* (Princeton University Press, Princeton).
Laughlin, G., Bodenheimer, P., and Adams, F. C. 1997, “The End of the Main Sequence”, *Astrophys. J.* **482**, 420-432.

LaViolette, P. A. 1987, "Cosmic-ray volleys from the Galactic center and their recent impacts on the Earth environment," *Earth, Moon, and Planets* **37**, 241-286.
Lineweaver, C. H. 2001, "An Estimate of the Age Distribution of Terrestrial Planets in the Universe: Quantifying Metallicity as a Selection Effect," *Icarus* **151**, 307-313.
Lytkin, V., Finney, B., and Alepko, L. 1995, "Tsiolkovsky, Russian cosmism and extraterrestrial intelligence," *Q. Jl. R. astr. Soc.* **36**, 369-376.
Newman, W. I. and Sagan, C. 1981, "Galactic Civilizations: Population Dynamics and Interstellar Diffusion," *Icarus* **46**, 293-327.
Norris, R. P. 2000, "How old is ET?" in *When SETI Succeeds: The impact of high-information Contact*, ed. A. Tough (Foundation for the Future, Washington DC), pp. 103-105.
Oliver, B. M. 1973, "Conclusions and Recommendations: Project Cyclops Study," *Icarus* **19**, 425.
O'Neill, G. K. 1974, "The colonization of space," *Phys. Today* **27**, 32-40.
Piran, T. 2000, "Gamma-ray bursts – a puzzle being resolved," *Physics Reports* **333/334**, 529-553.
Rampino, M. R. 1998, "The Galactic theory of mass extinctions: an update," *Cel. Mech. and Dyn. Astron.* **69**, 49-58.
Raulin-Cerceau, F., Maurel, M.-C., and Schneider, J. 1998, "From panspermia to bioastronomy, the evolution of the hypothesis of universal life," *Orig. Life Evol. Biosph.* **28**, 597.
Raup, D. M. 1991, *Extinction: Bad Genes or Bad Luck?* (W. W. Norton, New York).
Sagan, C. 1973, "On the detectivity of Advanced Galactic Civilizations," *Icarus* **19**, 350-352.
Sandberg, A. 2000, "The Physics of Information Processing Superobjects: Daily Life Among the Jupiter Brains," *Journal of Transhumanism* **5** (now *Journal of Evolution and Technology*, at http://transhumanist.com/volume5/Brains2.pdf).
Scalo, J. and Wheeler, J. C. 2002, "Astrophysical and astrobiological implications of gamma-ray burst properties," *Astrophys. J.* **566**, 723-737.
Shaviv, N. J. 2002, "The spiral structure of the Milky Way, cosmic rays, and ice age epochs on Earth," *New Astronomy* **8**, 39-77.
Shklovskii, I. S. and Sagan, C. 1966, *Intelligent Life in the Universe* (Holden-Day, San Francisco).
Tarter, J. 2001, "The Search for Extraterrestrial Intelligence (SETI)," *Annu. Rev. Astron. Astrophys.* **39**, 511-548.
Thorsett, S. E. 1995, "Terrestrial implications of cosmological gamma-ray burst models," *Astrophys. J.* **444**, L53-L55.
Tipler, F. J. 1980, "Extraterrestrial Intelligent Beings do not Exist," *Q. Jl. R. astr. Soc.* **21**, 267-281.
Tucker, W. H. and Terry, K. D. 1968, "Cosmic Rays from Nearby Supernovae: Biological Effects," *Science* **160**, 1138-1139.
Viewing, D. 1975, "Directly interacting extra-terrestrial technological communities," *J. Brit. Interplan. Soc.* **28**, 735-744.
Walker, M. A. and Ćirković, M. M. 2003, "Fermi Equation," in preparation.
Ward, P. D. and Brownlee, D. 2000, *Rare Earth: Why Complex Life Is Uncommon in the Universe* (Springer, New York).
Webb, S. 2002, *Where is Everybody? Fifty Solutions to the Fermi's Paradox* (Copernicus, New York).
Wilson, P. A. 1994, "Carter on Anthropic Principle Predictions," *Brit. J. Phil. Sci.* **45**, 241-253.

[1] Astrobiology comprises as a subdiscipline the field dealing with SETI-related studies, for which the term "xenology" is sometimes employed (cf. Freitas 1999).

[2] Which leads, obviously, to one of the best strategies of defense of technological development against religious, ethical, or ecological criticisms: we should invest in development of advanced technologies, since without them we are condemned to extinction anyway.

[3] It should be noted that religious or quasi-religious views on this issue, perhaps the last vestige of medieval Aristotelianism, still have strong influence in the scientific circles themselves. A particularly amusing example is the case of Guillermo Gonzalez, both a distinguished astronomer and Biblical apologist, expounded in the book of Darling (2001). Gonzalez has been a strong supporter of the "rare Earth" theory in both his scientific and religious writings.

[4] Of course, as one of the referees has kindly pointed out, this is far from being a monolithic attitude, and a wide spectrum of opinions has been voiced in discussions at conferences or mailing lists. However, rather extreme position taken, for instance, by Bostrom (2001) on this issue is certainly very influential, and the debate in general and many specific positions in particular will benefit if its weaknesses can be clearly demonstrated.

[5] Another point of contact is the relationship between SETI and AI enterprises, which includes all attempts to eventually define intelligence, consciousness, and related phenomena. We shall not enter this fascinating topic here further.

[6] Stephen Webb, in his recent monograph, so far the best historical introduction into the "Great Silence" problem (Webb 2002), dubs the relevant question Tsiolkovsky-Fermi-Viewing-Hart's. Main references are Lytkin, Finney, and Alepko (1995; for Tsiolkovsky), Jones (1985; for Fermi), Viewing (1975), and Hart (1975). We find it only just to add Tipler to list, since his von Neumann probe setup gives the whole problem completely new flavor (Tipler 1980), although he was not, as often mistakenly assumed, the first to propose self-replicating machinery for interstellar contact (e.g. Boyce 1979). Of course, it is best known simply as "Fermi's paradox".

[7] The best comprehensive recent treatment is the textbook of Dodelson (2003).

[8] For this fascinating subject in theoretical astrophysics, see Laughlin, Bodenheimer, and Adams (1997).

[9] In a recent abstract, Kenneth Brecher has suggested a third possible catastrophic effect of GRBs, namely its alleged capacity to perturb weakly bound cometary orbits in the Oort cloud (Brecher 1997). If it is confirmed, this will enormously strengthen the case for GRB-mediated global astrobiological regulation.

[10] The idea of Clarke (1981) that nuclear outbursts—similar to the ones observed in Seyfert galaxies—from the core of the Milky Way can lead to devastation of habitable planets throughout the Galaxy has been, historically, the first global-regulation mechanism proposed. However, it seems to be abandoned as we learn more about the center of our Galaxy. (For variations—now of "only" historical importance—on the same theme see Clube 1978; LaViolette 1987.)

[11] Notice that the anthropic selection effect (cf. Bostrom 2002) readily explains why that is so, in spite of the very low *a priori* probability. Humans could not arise prior to the phase transition, since there was no time for high-complexity life to evolve without being destroyed by cosmic rays and other detrimental consequences of GRB regulation (or cumulative effects of impacts, close SNe, spiral-arms crossings, runaway greenhouse effect, and other calamities). On the other hand, we could not arise later from the phase transition epoch for the same reason one does not expect to find a previously unknown stone-age tribe in the present-day Europe: high-complexity ecological niches do not allow spontaneous emergence of new lower-complexity lifeforms.

[12] I am indebted to Robert J. Bradbury for pointing out that the term "society" may be too restrictive in respect to plausible diversity of advanced stages in evolution of intelligence in the cosmic context. The word seems inappropriate, for instance to such entities like the "Jupiter brains" (Sandberg 2000) or "Matrioshka brains" (Bradbury 2001).

[13] One thing should be put straight here: I use the neutral term "rival" to denote civilizations which may influence us in both positive and negative (according to most established ethical systems) manner. Thus, an advanced ETI community may preempt human usage of (finite) material resources of the Galaxy or exert a powerful resistance on any human colonization of space; this still does not qualify it as an "enemy" or even an existential risk in terms of Bostrom (2001). On the other hand, it is entirely conceivable that the same advanced ETI community could manifest either a cooperative or a submissive behavior. In any case, it will present a powerful motivation for humanity to exercise its best creative and cognitive capacities, thus making a "rivalry" a very productive one, similarly to "fair sport" model of behavior.

[14] I am indebted to one of the referees for correctly pointing out that this could, in fact, be an impediment to SETI and an explanation of the “Great Silence” itself, since evolutionary pressures of colonization could favor secretive and uncommunicative races. While rather intriguing, this option belongs to the realm of sociological (or sociobiological) speculation which is hard to judge at our present level of ignorance. On the other hand, it is reasonable to assume that activities of advanced **and** colonizing civilizations will be detectable even if the level of intentional communications is kept at minimum.

[15] For O'Neill's colonies, see the original proposal in O'Neill (1974); terraforming is discussed in numerous papers, for instance Cathcart (1991); Fogg (1995). For stellar uplifting see Criswell (1985).