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CATASTROPHISM, FINE-TUNING AND CHANGING VIEWS OF EXTRATERRESTRIAL LIFE AND INTELLIGENCE

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Abstract. I briefly consider the impact of recent developments in astrobiology, planetary sciences and philosophy on our changing historical perspective of extraterrestrial life and intelligence. In particular, I focus upon the re-emergence of catastrophism in Earth and planetary sciences, which is no more – in sharp distinction to the historical experience of $19^{\rm th}$ and the first half of $20^{\rm th}$ century – associated with the terrestrial exclusivist and the belief in uniqueness of human intelligence. On the contrary, several recent astrobiological hypotheses emphasize the complete inversion of this perspective in looking at global catastrophic mechanisms as keys for understanding biological evolution on the widest spatial and temporal scales of the Milky Way. Shifting perspectives of the physical preconditions for the emergence of life and intelligence and reducing the controversial "fine tuning" of the universe for life to a set of observation-selection effects has significantly contributed to the development of this set of ideas.

1. INTRODUCTION

This brief essay touches upon three distinct topics, provocatively conjoined in the title: the old/new doctrine of catastrophism, the (in)famous anthropic fine-tunings and our views of extraterrestrial life and intelligence. Here I wish to sketch the connection which exists between these three seemingly separate and independent fields and to suggest that there is a basis for a unified philosophical study. This is prompted by quite recent – from a historian's and philosopher's standpoints – dramatic changes in both astronomical and planetary sciences, as well as in philosophy of science.

Several key studies in 80s and 90s – notably those of Michael J. Crowe (1986) and Steven J. Dick (1996) – have presented the historical values of differing and evolving view on extraterrestrial life and intelligence. This extremely valuable work had a specific historical focus on the questions of pluralism (of inhabited worlds) and philosophical preferences. It was to a large degree characterized by a "post-Kuhnian" thesis which can be explicated as follows: *the debates on ET life among astronomers tell us more about astronomers than about life in the universe.* We wish to argue here that recent developments in a number of different fields prompt the re-assessment of this thesis. The main relevant trends which determine this re-assessment are:

- Astrobiological "revolution" (1995-today)
- The rise of (neo)catastrophism (1980-today)
- Elaboration of anthropic principle(s) as observation-selection effects; new role for fine-tuning in string cosmology (cca. 1993-today)
- The rise of transhumanism and increased considerations of postbiological evolution (cca. 1990-today)

In other words, we are entering the next phase in the discussions of ET life – the one focusing on the object itself. By rejecting some of the old-fashioned prejudices in both Earth-sciences and cosmology, as well as adopting new elements in our philosophical and methodological approach we can arrive at much better epistemical framework for scientific treatment of this problem.

2. ASTROBIOLOGY AT THE "COSMOLOGICAL STAGE"

We are lucky enough to live in an epoch of great progress in the nascent discipline of astrobiology, which deals with 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? A host of important discoveries has been made during the last decade or so, the most important certainly being a discovery of a large number of extrasolar planets; 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; the development of a new generation of panspermia theories, spurred by experimental verification that even terrestrial microorganisms easily survive conditions of an asteroidal or a cometary impact; progress in methodology of SETI studies, etc. (for recent beautiful reviews see Des Marais and Walter 1999; Darling 2001; Grinspoon 2003). However, the epistemological and methodological basis of astrobiological and SETI studies presents us with a hornet's nest of issues which have not been, with few exceptions, tackled in the literature so far.

As an example of a new and fruitful **theoretical concept** introduced by modern astrobiology let us mention the Galactic Habitable Zone (henceforth GHZ; Gonzalez, Ward & Brownlee 2001; Lineweaver, Fenner, and Gibson 2004). This is a region within our Milky Way galaxy – and, by analogy, other spiral galaxies – where habitable terrestrial planets can occur and, consequently, where we may expect life and intelligence. Outer boundary of GHZ is clearly determined by the metallicity gradient – at some galactocentric distance the abundance of metals drops below the critical threshold for formation of terrestrial planets (and possible terrestrial satellites of gaseous giants). Much less clearly defined inner boundary determined by an interplay between the dynamical stability, frequency of supernovae/gamma-ray bursts, and possibly cosmogonic restrictions Thus, we cannot yet talk about precise weights for astrobiological and SETI searches within GHZ, but can, for instance, fairly confidently estimate that GHZ comprises $\sim$20% of the Milky Way stellar population.

This example illustrates the state of flux and transition characteristic for contemporary research on the life in the universe. The number and importance of foundational problems testify on the early, formative stage of the discipline (cf. Kragh 1997). Astrobiology seems to be today in roughly similar stage to the physical cosmology in 1930s and 1940s (some key facts are in, but there is no satisfactory overall theoretical framework; for the best review, see Kragh 1996). If this conjecture is correct, our understanding of life in the cosmos follows a similar path to our understanding of the cosmos itself – with about 75 yrs delay. Even contemporary detractors of astrobiology have been foreshadowed in logic and methodology by the "classical" criticism of physical cosmology (Dingle, Bunge, etc.). Many personal careers/interests of some of the leading contemporary astrobiologists support the analogy (Charles Lineweaver, Paul Davies, Chris Chyba, Max Tegmark), since they have shown interest and have done active research either in cosmology itself, or on relevant philosophical and methodological issues.

3. CRUCIAL INGREDIENTS – NEOCATASTROPHISM AND ANTHROPIC REASONING

Another key ingredient of the suggested philosophical overturn of our views of extraterrestrial life and intelligence is the rise of neocatastrophism – rather vague term which, nevertheless, signifies an important shift in our outlook in Earth and planetary sciences. "Classical" catastrophism of the 19^{th} century, as represented by Cuvier, de Beaumont, Orbigny or Murchison, has been defeated by its great uniformitarian alternative, personified by Darwin's teacher, Charles Lyell, and his monumental *Principles of Geology* (1830-1833). There were, however, at least two types of uniformitarianism: **substantial uniformitarianism** (uniformity of law), and **gradualism** (uniformity of rate of natural processes). The confusion (and intentional obfuscation!) between the two strongly contributed to the victory of uniformitarians (e.g. Gould 1987).

Uniformitarians remained predominant for about a century and a half, and the legacy of this long-standing orthodoxy has been distinctly mixed. While a great progress has undoubtedly been achieved, in many places did the gradualist dogma actually obstructed research, as in the notorious case of Wegener's continental drift hypothesis. Gradualism has shared with the old catastrophism the preference for uniqueness of the Earth and life – in those rare cases when the issues have been seriously studied (e.g. by Alfred R. Wallace, co-discoverer of natural selection).

The seminal study of Alvarez et al. (1980) – strongly arguing that the mass extinction at the Cretaceous-Tertiary boundary has been caused by the impact of an extraterrestrial body – spelled the overthrow of gradualism and the beginning of the more complex views, usually labeled together as neocatastrophism (e.g. Palmer 2003). Significantly increased scope and spectrum of catastrophic events influencing evolution of life on Earth (and, presumably, elsewhere) motivated a lot of work in several different fields. The emergent paradigm suggests that the evolutionary trajectory in a vast biological morphospace which led to the present-day intelligent beings has been result of both law-like trends and contingent, essentially stochastic overturns resulting from the global catastrophes discernible in geological record. On a smaller

timescale, this (fractal?) pattern may be repeated in historical times with rises and falls of human civilizations (e.g. Clube and Napier 1984, Clube 1995), although the evidence here is much weaker.

But how typical – or how extraordinary – is the contingent history of Earth in comparison to a typical planet in the Milky Way?[1] In order to address this question, we need a theory of observation-selection effects; fortunately, this has been forthcoming for quite some time, although often misunderstood, under the title of the anthropic principle and anthropic reasoning in general. Empirical fine-tuning of the universe and Earth has often been misconstrued to offer support for design or some other teleologial scheme. An excellent antidote for this is the recent tendency to construe the anthropic principle as set of observation-selection effects (Bostrom 2002). This does not only imply that, contrary to frequent misuse and popular press, the anthropic principle is **disteleological**, but also opens a door to its broad application in the astrobiological framework. In a sense, the anthropic principle can play a similar role in the development and legitimation of astrobiology as a dynamical new discipline which was played by the cosmological principle of Eddington and Milne and other "philosophical" principles abound in the cosmological discourse of 1930s and 1940s. While it is easy – and patently ahistorical! – to argue that those have gradually ceased to exert dominant influence in the cosmological thinking, especially after the solidifying of the standard cosmological model in early 1970s. It should be mentioned that it is sometimes controversially argued that epistemic status of the anthropic reasoning depends on the existence of multiple cosmological domains, but it is not strictly necessary in order to apply it in astrobiology. In addition, even if it were necessary, a plausible framework for such a construal offer recent advances in theoretical physics and cosmology, notably the development of the ideas of the anthropic landscape of string theory (Susskind 2003) or the multiverse cosmologies stemming from Linde's chaotic inflation (Linde 1990) or from philosophical considerations (Tegmark 1998).

In general, re-formulation of AP as a set of observation-selection effects enables building of a general Bayesian theory of preconditions (cosmological, physical, chemical) for observership. This directly returns us to the issue of extraterrestrial life and intelligence which needs to conform to the same set of such universal preconditions. In particular, the most frequently cited argument against extraterrestrial intelligence is encapsulated in Enriko Fermi's lunch question: "Where is everyone?" also known as Fermi's paradox or the "Great Silence" paradox (for reviews see Brin 1983; Webb 2002). What has not been appreciated enough is that Fermi's paradox became more disturbing as of late, especially after the study of Lineweaver (2001) showing that the average age of terrestrial planets is by $\sim$1.8 Gyr greater than the Earth's!

Many solutions have been proposed in already long history of Fermi's paradox. However, the important hidden truth is that **Fermi's paradox follows from gradualism**. If we wish to retain naturalism vis-à-vis origin of life and intelligence, and reject gradualism, we can answer both Fermi's paradox and other problems raised against ET life (e.g. Carter's "anthropic" argument). There is a class of astrobiological hypotheses ("phase-transition" models) which explicates conditions for avoiding

[1] Of course, the same question can be posed in respect to the typicality of the Milky Way galaxy itself – or

all these problems (Annis 1999, Ćirković 2004a,b). This is still widely unappreciated, at least partially due to philosophical prejudices, although the times are clearly changing.

In an ironic twist, the forthcoming paradigm is best expressed in words of Steven J. Dick, who in an intriguing recent (2003) paper wrote:

> But if there is a flaw in the logic of the Fermi paradox and extraterrestrials are a natural outcome of cosmic evolution, then cultural evolution may have resulted in a postbiological universe in which machines are the predominant intelligence. This is more than mere conjecture; it is a recognition of the fact that cultural evolution - the final frontier of the Drake Equation - needs to be taken into account no less than the astronomical and biological components of cosmic evolution.

Further, Dick goes forward to give a suggestive illustration of the possible guideline of such am advanced evolutionary trajectory:

> In sorting priorities, I adopt... the central principle of cultural evolution, which I refer to as the Intelligence Principle: the maintenance, improvement and perpetuation of knowledge and intelligence is the central driving force of cultural evolution, and that to the extent intelligence can be improved, it will be improved.

Even if we regard this suggestion as merely a placeholder for the future ideas, it is worth further study as an example of hitherto unexplored parts of the evolutionary space. In addition, at such an early stage, philosophical arguments are fully entitled to play an important role in this discussion.

4. INSTEAD OF CONCLUSIONS

Inversion of perspectives regarding catastrophism and preconditions for life and observership creates conditions for a fruitful **philosophy of astrobiology**, concentrated upon the subject of extraterrestrial life and intelligence itself. Contemporary research on life in the general cosmic context offers a lot of material for philosophical and historical study – and it will continue to do so for a long time to come![2]

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