INTERSTELLAR CONTACT IN AN EVOLVING UNIVERSE

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Abstract

The evolution of organization in the universe is considered. It is proposed that a circum-solar community, and eventually a galactic community represent the next levels of organization in this evolutionary process. Possible strategies for detecting other technological civilizations in the galaxy are discussed.

1. INTRODUCTION

"When I see Thy heavens, the work of Thy fingers, the moon and the stars which Thou hast formed; What is man that Thou shouldst think of him...?" (1)

The modern answer to this age-old question is that mankind is a relatively insignificant phenomenon in the universe, whose existence or activities are of no cosmic consequence. In Part II of this paper, I wish to re-examine this question, and to suggest that mankind has a role to play in the evolution of the universe. Such activities as space colonization, SETI*, and UFO research would seem to be the key to realizing this potential. In Part III, I discuss the strategy for SETI, taking into account the implications of interstellar colonization. It will appear that SETI and UFO studies are two facets of the same investigation.

2. MANKIND IN A COSMIC PERSPECTIVE

2.1 EVOLUTION OF PHYSICAL STRUCTURE

It is well established that the universe is expanding and, on the balance, present evidence suggests that it may continue to do so forever (2, 3). The history of material organization in such a universe runs something like this (4), the details, of course, still being the subject of research:

In the first 100 μs, the universe was flooded with all manner of particles and antiparticles, hadrons continuously being created and destroyed in high energy reactions. As the universe expanded and cooled, these reactions ceased and, up to a time 10-100 s after the beginning, the universe was dominated by leptons. At a time ∿30 s, electrons and positrons begin to annihilate faster than they were created, leaving only a small residual distribution. After about one hour, helium formed. Up to this point in time, there was little one could say about the microscopic organization of matter but, now, some 20% of the protons were intimately coupled with another proton and two neutrons. After about a million years, the universe had cooled to 3000 K, and nuclei and electrons combined to form neutral atoms, thus further increasing the organization of matter.

Inhomogeneity in the early universe left its imprint on this primordial matter, and local density enhancements condensed under self-gravitation. At some stage, whether before, during, or after the

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*SETI: the electromagnetic Search for Extraterrestrial Intelligence.

formation of galaxies, some matter collapsed directly to densities and temperatures which initiated nuclear reactions and the first stars were formed. Thus organization continued, as matter was processed to form more complex nuclei such as carbon, oxygen, and nitrogen. It is speculated that those early stars were so massive that they became supernovae in which the heavy elements were formed (e.g.: 5).

After the initial formation of the elements, it became possible to form clouds of dust and molecular gas as we know them today. Here, atoms are combined into molecules and crystal lattices. As these clouds contract, the possibilities for chemical reactions increase and more complex molecules form. Eventually, some of these condensations reach a critical level and collapse to form a stellar system. Somewhere at this stage, whether in the protostellar cloud or subsequently in the atmospheres and oceans of planets, life formed.

2.2 DISSIPATIVE STRUCTURES

One occasionally finds examples of spontaneous organization in the physical world which are temporary in the sense that they are maintained by some external influence. Convection is a simple example. A gas or fluid in a gravitational field is removed from thermodynamic equilibrium by being heated from below. At a critical value of the temperature gradient, convection patterns arise spontaneously. Prigogine and his co-workers (6) have considered such structures, which arise by virtue of some nonlinearity in the laws which describe the system. Because these structures are created when a continuous flow of energy and/or matter from the outside world maintains the system at some critical level from equilibrium (that is, a minimum level of dissipation), they are called <u>dissipative structures</u>.

Eigen (7) has considered in detail the application of these thermodynamic principles on the level of molecular kinetics and has shown how biological macromolecules could have arisen. (See also Ref.8.) For illustrative purposes only, consider what would happen if a self-replicating molecule were to form. (In nature, replication involves the cooperative interaction of molecules in a "hypercycle".) The self-organization of matter would then, become a runaway process: the abundance of the molecule would increase exponentially to an equilibrium level determined by the rate at which new raw materials are formed and the product molecules are destroyed (≡ "survival of the fittest".) This molecule would then be available as the raw ingredient for yet a higher level of organization.

Whereas a molecule, if it is stable, exists in its own right, biological systems, however simple, are true dissipative structures. Even a simple cell requires a constant input of raw materials to maintain itself. Organisms (being organizations of cells) and societies (being organizations of organisms) are in turn more complex dissipative structures. Thus, a city is maintained only by virtue of a constant input of matter and energy.

Figure 1 (taken from ref. 9) is a summary of the structural organization of matter. At each level in the table, the component parts are of the same kind. At the left of the table, however, are examples of aggregates with a low degree of organization, whereas on the right the examples exhibit a high degree of organization. Further, the highly organized entities on the right at any level of the table are the building blocks for the aggregates on the next level down. In this view, social evolution is not an analogue to biological evolution, but a direct descendant of it.

2.3 EVOLUTION IN THE FUTURE

We have recently come to appreciate that there is an essential unity to the entire planet. Not only are the vast majority of human societies interdependent (although some isolated pockets may be found), but all of mankind is in turn dependent on the state of the biological world. Ecology has become an international concern. Thus, our immediate objective on Earth is to find an equilibrium which represents organization on a planetary scale.

The theory presented in subsection 2.2 does not predict that there must be a higher level of organization but indicates that it is probable if a physical mechanism exists. We can very well imagine the establishment in circum-Solar space of independent ecosystems. Space colonization would be a first and hardest step in this direction. At some time in the future, mankind may thus occupy habitats which are ecologically independent, an advantage for the survival of the species. Undoubtedly, some form of organization will bind these together to facilitate the exchange of raw and processed materials, and information.

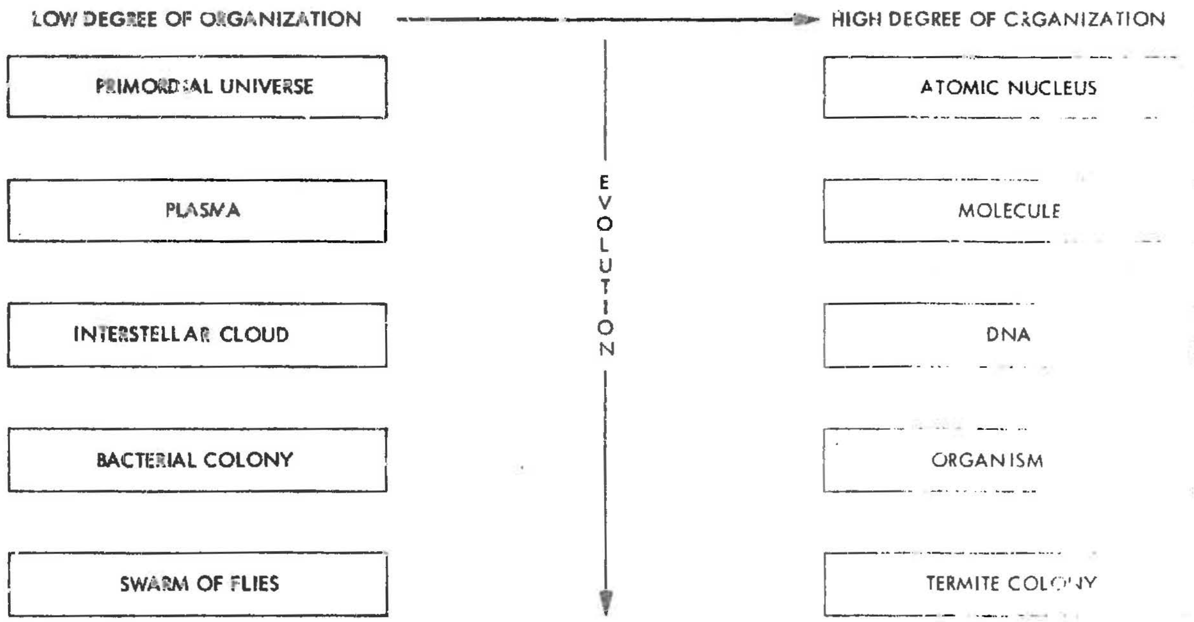

Figure 1. ORGANIZATION IN THE UNIVERSE

In the same way, a galactic organization seems possible. Even if star-bound civilizations communicate only electromagnetically, such contact could profoundly alter the communicating societies (10) in a way which depends on this contact. Thus, to search for other civilizations is to take the first step towards participation in a higher evolutionary state. In the next section we consider how such a search may be conducted.

3. SEARCHING FOR EXTRATERRESTRIAL CIVILIZATIONS

3.1 TRADITIONAL APPROACH

Mainstream scientific thought has focussed on the search for electromagnetic signals of extraterrestrial origin (rather than, say, UFO investigations) as the mechanism for finding evidence of other civilizations in the galaxy. Generally, three assumptions have been made (11):

(1) We are not unique as a technological civilization in our galaxy.

(2) Interstellar travel for the purposes of "manned" exploration or colonization never reaches the level of feasibility or practicality.

(3) Interstellar beacons meant for contact between civilizations are likely enough to warrant intensive searches.

While, in point of fact, there are no compelling arguments to support assumption 1, the circumstantial evidence is encouraging (p. 1-186 in Ref. 12 and Ch. 2 in Ref. 13). However, it should be borne in mind that there are also reasons to believe that the number of suitable planets, and hence the rate of emergence of technological civilizations, may be considerably smaller than is generally believed (9, 33, and references cited therein).

Assumption 2 has been eloquently argued by many proponents of SETI (for example, see ref. 14, and Ch. 4 in ref. 13). Basically, the argument is that methods of travel imaginable within the constraints of physics as we know it require round trip travel times that exceed the human lifetime, even to reach the nearest stars. We will examine this argument in subsection 3.2.

From Assumption 2 it follows that galactic civilizations must contact each other electromagnetically. To initiate communication, one participant must first broadcast a beacon to facilitate detection by the other party. The suggestion by Cocconi and Morrison (15) that such beacons might exist has been the basis for all subsequent orthodox SETI planning (p. 230 ff in ref. 12; Ch. 4 in ref. 13; 16).

The consequent strategy has generally been to search a large number of stars to very sensitive levels for narrow band signals at selected frequencies (17). Other approaches have also been taken, for example, to search for strong pulsed signals (p. 241 and p. 258 in ref. 12), or to search for narrow band signals over the entire sky and over a wide range of frequencies (15). In all cases, by virtue of assumption 2, it is generally expected that the signal would originate at a large distance from the Earth. One exception was presented by Bracewell (18), who qualified assumption 2 to the extent of proposing unmanned probes between stellar systems; thus our first signal might be found in our own solar system.

This traditional approach to SETI has recently been challenged by a number of authors (19, 20, 21, 11, 22), primarily on the grounds that assumption (2) cannot be valid. These arguments are considered below.

3.2 WHERE ARE THEY? - INTERSTELLAR TRAVEL

That interstellar travel, per se, is possible has been accepted for many years (23,24). The feasibility of interstellar missions has been considered in Project Orion and Project Daedalus (25). The main difficulty in imagining manned interstellar travel was the question of voyage duration, as noted above. This, apparently, was considered to be a sufficient obstacle to rule out interstellar travel, although Öpik (26) wisely did not leap to this conclusion. Hart (19) has noted several ways in which the long travel times might be overcome, but perhaps the most convincing stems from the recent feasibility studies on self-supporting habitats in space. Matloff (27) has described an "interstellar Ark" which combines an O'Neill Model I space colony (28) with a thermonuclear rocket motor (e.g., 29).

We can then imagine a scenario for galactic colonization: a home planet sends out several arks to the nearest suitable stars. A few generations later the colonists arrive and start new civilizations. Over a period of some generations, these civilizations mature sufficiently to send out arks of their own. In this kind of a process, even with very conservative numbers, the time required to colonize the entire galaxy is very short compared to the age of the galaxy (19, 20, 11, 22). In view of this, if the evolution of technological civilizations is not extremely rare, we would expect the galaxy to be extensively colonized.

A variety of objections to this conclusion may be imagined. For example, civilizations may not last long enough to start the process of colonization. The difficulty with this and all other arguments of this kind is that it must apply to every civilization that has ever arisen in the history of the galaxy. Even if, for example, only one in a hundred civilizations reached the colonization stage, the galaxy would be full unless there have been less than one hundred such civilizations (i.e. - one per billion stars). Hart (19) considers various objections in detail, and Singer (22) treats the probabilities involved quantitatively. If the galaxy is empty, it is only because technological civilizations are extremely rare at this time.

In view of this, Hart (19) argues that, since there are no intelligent beings from outer space on Earth now (i.e. - because they have not colonized the Earth), they do not exist; the galaxy is empty. Ball (30) anticipated this argument by proposing that Earth is set aside as a wilderness area, which is specifically avoided by the advanced civilizations in the galaxy. Hart (19) applied the probability argument cited above, by asserting that not all the societies in the galaxy could be expected to observe this "taboo". Kuiper and Morris (11), however, noted that the taboo need only be observed by the civilization which has effective control of this part of the galaxy. Singer (22) recognized that this is a serious challenge to Hart's conclusion, but questioned whether that civilization could be expected to observe this taboo continuously over a period of time perhaps as long as 10^9 y. Kuiper and Morris (11), however, suggested that we may not be so much avoided as ignored, that there may simply be no reason why an advanced alien civilization would want to initiate formal contact. In this regard, it is worth bearing in mind that there are still primitive peoples on this planet who have no awareness of the advanced technological civilization which now encompasses nearly the entire world.

3.3 NEW APPROACHES TO SETI

The arguments presented above suggest that, if technological civilizations are not extremely rare in the galaxy, our solar system probably been visited at some time, at least by an unmanned probe, and perhaps manned exploratory visits. So, while the present evidence for visits by extraterrestrials in historical times seems rather weak (for example, ch. 12 in ref. 31), the possibility is a reasonable one and it behooves ancient historians and archeologists to re-examine their data in this light. (Equally, rebuttals of some rather far-fetched interpretations presented to the public might be valuable.)

There are at least two situations in which repeated visits by extraterrestrials might be expected. De San (32) has suggested that if the galaxy has been extensively colonized for a long time, then many stellar systems would subsequently have had to be abandoned as these stars evolved to the red giant phase and beyond. The populations of these systems would be forced to make their home in space, other systems already being occupied. Thus, the galaxy might have a substantial itinerant population, perhaps wandering from star to star, subsisting by trade or similar activities. In this case, the solar system could expect repeated visits, and some of these visitors would probably come to the Earth.

Papagiannis (33) has pointed out that beings who have travelled over interstellar distances are adapted to life in space, in the sense that they have developed artificial environments ideally suited to them. A resident of, say, San Diego or Palo Alto, who would be dismayed at the thought of living in Washington, D.C., or Dallas, Texas (or Sydney, Australia, or Montreal, Quebec, etc.), can easily appreciate why space colonists might prefer to settle in some convenient orbit and build there. Papagiannis (33) proposes that the asteroid belt might be particularly attractive because of the availability of raw materials. In this case also would we expect the earth to receive occasional visits.

These two examples are interesting because they demonstrate that reports of extraterrestrial visitors should be taken seriously, at least to the point of meritting close examination. Curiously, if the UFO phenomenon is approached with the point of view of looking for evidence of extraterrestrial visits, it is precisely the "strangest" reports, close encounters of the second and third kind (34) which are the most easily understood. On the other hand, the foregoing cannot be considered a defense of the extraterrestrial hypothesis for UFO's, since both scenarios could be valid (even simultaneously) without any visits to the Earth.

In the absence of physical evidence of extraterrestrials on earth, we must for the present resort to astronomical techniques for SETI. Papagiannis (33) has suggested that infrared studies of asteroids could be conducted to see whether any have anomalously high brightness temperatures, in the vicinity of 300 K. (A similar test of stellar infrared sources has previously been suggested by Dyson, ref. 35.) Papagiannis (33) also proposes radio monitoring of selected asteroids for leakage signals; this could easily be incorporated into a comprehensive radio SETI program.

Looking beyond our solar system, a radio SETI program might anticipate two kinds of signals in an extensively colonized galaxy (11).

(1) A radio beacon meant for contact might be beamed at the earth. This would be the case if extraterrestrials wished to reveal themselves to our society at its present technological level, but in a manner which would least perturb our civilization.

(2) Signals not intended for our earthbound civilization might be beamed toward the solar system. These might form a communication link between distant extraterrestrial beings and local ones (i.e., inhabitants of the asteroids), or alien artifacts (i.e., probes) in our systems.

In both these cases, we would expect the signal to originate from one of the nearer sites occupied by the alien civilization, so that an intensive examination of the nearest few hundred stars should suffice. (Morris and Kuiper, ref. 11, note, however, that communications signals using advanced coding schemes might be difficult to detect.) The searches by Zuckerman and Palmer at the 21 cm line of hydrogen, and by Bridle and Feldman at the 1.3 cm of water (17) represent the beginning of such a search. Considerable improvements, however, can be made in terms of frequency coverage, spectral resolution, modulation analysis, polarization characteristics, and sensitivity.

Whereas the arguments presented in subsection 3.2 perhaps weaken the case for expecting beacons within our galaxy, the traditional reasoning still applies for intergalactic distances. Indeed, the case for extragalactic SETI seems stronger. It seems quite probable, for example, that a technological civilization has evolved in the Andromeda Nebula, and that this civilization is quite advanced, having established itself throughout that galaxy (by the same arguments as were used in subsection 3.2). By the laws of physics as we know them, it would seem that contact between the Andromeda Nebula and our galaxy would be primarily electromagnetic. Thus, it might well be possible and even probably that the Andromedans are beaming radio signals at us. Sagan and Drake (17) are conducting a search of several nearby galaxies at wavelengths of 21, 18, and 13 cm. Unfortunately, there are still reasons why such a SETI might fail. Since the signals would be from an advanced civilization, they might be intended for a correspondingly advanced civilization (one which could reply) and thus might have a character we would not recognize. Or, the beacon might have sent aeons ago, been detected by an advanced civilization in our galaxy, and since been supplanted by tightly beamed communications signals which we could not detect.

The preceding discussion has been concerned with what one might reasonably expect and not except by way of electromagnetic ETI signals. However, our experience is rather limited and our expectations might be quite wrong. Consequently, any serious attempt to conduct a comprehensive radio SETI should include some search modes which contain as little bias as possible. One example is the all-sky, all-frequency search for narrow-band signals described by Murray et al (16). At this early stage, our radio SETI efforts should attempt to achieve some balance between tests of specific hypotheses and general surveys for unexpected signals.

4. MANKIND IN THE GALAXY

Hopefully, the coming years will see increasing efforts to find evidence of extraterrestrial civilizations. Yet, contact may not come until "we" go to "them". By analogy, if an isolated Amazon tribe became aware of our technological society, it would be up to them to trek through the jungle to the nearest outpost of civilization. Even then, they might get a rather indifferent reception for their efforts. I suggest therefore that the surest way to proceed is as if we were alone.

Ehricke (36), Lunan (31), and Michaud (37) have described various aspects of how mankind might proceed on a program of interstellar colonization. It seems probable that we would then soon encounter the galactic community. If we do not, then such a community would come into being as mankind proliferates throughout the galaxy. It is difficult to predict what such a community might be like, but many interesting speculations are to be found in science fiction literature.

Within the constraints of current physics, a galactic community would be slow-moving by our standards. Information transmitted from the centre of the galaxy would take 30,000 y to get this far out into the disk. Thus, the minimum meaningful time interval for a galactic community would be ~100,000 y. If we imagine that the community has existed for a billion years, then it has experienced only 10,000 such intervals; in other words, the community is still quite young and is probably still developing. There should be many opportunities for a young and vigorous species to make significant contributions. And, of course, there is yet the possibility that we can be the founding father of the galactic community.

A galactic society is not, of course, the ultimate achievement of evolution, for there are other galaxies. . . .

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7. BIOGRAPHY

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