ON THE QUESTION OF INTERSTELLAR TRAVEL

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ABSTRACT: Arguments are presented which show that motives for interstellar travel by advanced technological civilizations based on an extrapolation of Earth's history may be quite invalid. In addition, it is proposed that interstellar travel is so enormously expensive and perhaps so hazardous, that advanced civilizations do not engage in such practices because of the ease of information transfer via interstellar communication.

1. WHY SETI?

The study of "Life in the Universe" is a core NASA thrust. Prior to the space age, there was great speculation regarding the existence of life on other bodies within our Solar System. With the advent of space exploration, one of NASA's major objectives has been the search for life beyond the Earth. Great care was taken in the gathering and quarantine of the lunar soil samples returned by the Apollo flights. This was not so much because we were afraid of some deadly lunar virus, but rather to protect the lunar samples from back contamination which would have masked the analysis for extraterrestrial organisms. We know now, of course, that the moon is devoid of life.

As more and more data from our Mariner, Pioneer, Viking and Voyager planetary missions were analyzed, the case for life elsewhere in our solar system became increasingly grim. With the exception of possible fossil evidence of past life on Mars, many scientists today believe that our search for life in our solar system will reveal that we're it!

In our quest for the discovery of life elsewhere, we must now turn to the stars. Since we do not today possess the technological capability to physically travel over interstellar distances in a reasonable time, we must instead look outward for evidence of extraterrestrial life. After much thought and deliberation, the consensus is that our best bet in the search for intelligent life elsewhere is to look for narrowband signals produced by extraterrestrial intelligence in the microwave region of the electromagnetic spectrum.

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 449 - 454.

2. N

It is almost impossible to think about SETI without speculating on the possible number, N, of communicating civilizations coexisting in the galaxy today. Because of the large uncertainty in the various parameters of the Drake equation, N can be "determined" to be almost any value from very small to very large, depending on one's particular biases. I feel strongly, however, that exercises in the calculation of N are really quite irrelevant to SETI. SETI is simply the application of a scientific approach to the hypothesis that N may be greater than one and that our nearest neighbor, if such exists, may well be within communication range.

I find it rather amazing that some scientists (a small but very vocal minority) present arguments based on outrageous assumptions regarding the motives of advanced civilizations, and from no data, conclude that we are surely alone in the galaxy (and perhaps the Universe) and that therefore the pursuit of SETI is a complete waste of time and effort. Their "proof" for this conclusion is simply that if advanced technological civilizations ever existed, they should have developed interstellar travel capability perhaps billions of years ago and that even at a very small fraction of the speed of light, they would have completely colonized the entire galaxy long ago and should be present in our solar system today. But, they are not here, therefore they are not there!

This conclusion is blatantly absurd for it is simple to postulate the completely opposite conclusion from the same nondata. They are not here because they are all "out there" talking to one another and, therefore, there is no need or desire to engage in extensive interstellar travel!

3. WHY INTERSTELLAR TRAVEL?

I can think of only three legitimate motives for interstellar travel: colonization, survival, and exploration (quest for knowledge). The colonization scenario involves extrapolation of historical human colonization needs and desires into our own very far advanced technological future. Our past motives for colonization were driven by social, religious, political and economic pressures as well as the desire for new living space. It is clear, however, that long before we might achieve the technological capability to travel to the stars, we must come to equilibrium with planet Earth. If we do not, we may very well become extinct. Our population growth and the pollution of our environment must stop. We must recycle our resources and develop new, cheap and inexhaustible energy sources and attain world peace and stability or we won't be around to colonize anything. This will very likely take place in the next few hundred years or so, and at that point our motivation for colonization may no longer exist or at best be far less compelling than in our past.

With environmental and social stability, interstellar colonization gains us nothing. We simply move from one very stable and reliable

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energy source (our Sun) to some new energy source (the next star down the line) involving a very long, tedious and perhaps hazardous journey. The trip may take generations to complete, so that when we arrive we have lived in our spaceship for so long that planetfall might be highly distasteful. On arriving at the new planetary system (I assume we checked for planets before we left) we have facing us only two possibilities. We either land on a barren planet and proceed to terriform it or we land on a planet with indigenous, primitive life forms and prepare ourselves to cope with the possible incompatibilities in our differing biochemistries. With these two prospects awaiting us, I think I'd rather stay safe and snug in my own spaceship, which now makes me wonder why I ever came in the first place.

Interstellar travel for the purpose of survival makes no sense at all. If our Earth is threatened by some impending global catastrophe and we have the requisite technology, we can simply go somewhere else in our solar system. In approximately five billion years or so, our Sun will move off the main sequence and go through the red giant phase. This phase may last many hundreds of thousands of years. The photosphere might expand outward as far as the orbit of Mars and would, of course, turn the Earth into a cinder. I am quite sure, however, that if we are still around when this happens, we most certainly will have the technology to move into space habitats and locate ourselves beyond the orbit of Jupiter. As our Sun leaves the red giant phase and shrinks to a white dwarf, we could simply move our space habitats inward to whatever distance from the Sun gives us the energy flux level we desire. In the white dwarf state, a star like our Sun could continue to provide the energy needs of an advanced civilization for many tens of billions of years. This, by the way, is the reason why white dwarfs may be good candidate targets for SETI observations.

Stars much more massive than our Sun would be expected to undergo the cataclysmic death of a supernova. In a supernova, the star undergoes a gigantic explosion which would completely destroy any planetary system. But survival here may be a moot point since stars much more massive than the Sun may not survive in stable form long enough for any life to form and to evolve to intelligence.

It is quite conceivable that advanced civilizations might explore a few of their nearest neighboring stars for the sole reason of curiosity and quest for knowledge. We ourselves may do this sometime in our distant future. This exploration is most likely achieved using robot probes returning observational data at the termination of a long interstellar journey which might take hundreds of years to complete. The data so gathered would then have to be anlayzed and interpreted in order to gain information on the new star and its planetary system. Beyond this, the sending of a myriad of probes all over the galaxy for exploration purposes may never be done by any advanced civilization for two very specific reasons: (1) the high cost, high possible risk and slow data return associated with interstellar travel, and (2) the prior contact and establishment of communication with extraterrestrial intelligence.

As will be shown below, interstellar travel is very expensive (from an energy consumption point of view), and at high speeds could very well be quite hazardous without adequate protection that might be cost-prohibitive. Interstellar travel at slow speeds, on the other hand, seems a much safer and less costly endeavor, but the data return might be unacceptably slow for the investment involved. It seems obvious that the biggest deterrent to interstellar travel for exploration purposes is the establishment of communication links among advanced civilizations. Why bother with slow, expensive interstellar probes when we can transfer information directly, on any subject, at a very low cost, at the speed of light?

I cannot leave this subject without commenting on the scenario of Tipler (1980) wherein he suggests that an advanced civilization would send out self-replicating probes (von Neumann machines) that would eventually settle on every suitable stellar system in the galaxy in a time much less than the age of the galaxy. In the context of a galatic network of communicating advanced civilizations, this might be an exceedingly dangerous practice. First of all, the word that some dim-witted civilization was polluting the galaxy with self-replicating machines (without even a galactic environmental impact statement no less!) would spread at the speed of light. Second, the "Federation" now certainly would have the motivation to construct an interstellar vehicle whose sole purpose would be the annihilation of the polluting culprit!

4. IS INTERSTELLAR TRAVEL FEASIBLE?

I think the answer to this is probably yes. Whether or not the cost and hazards of interstellar flight are outweighed by the need or desire to engage in such activities is quite another matter. As discussed in the Cyclops Report, (Oliver and Billingham, 1973) the best you can do and still obey the known laws of physics is a hypothetical, 100% efficient, relativistic photon rocket driven by matter/antimatter annihilation. In a round-trip powered flight to the Alpha-Centari system (4.3 light years) at approximately 0.7c, a spaceship weight on the order of 1000 tons might be required to support a reasonably sized crew for what would be at least a 13 year (ground elapsed time) journey. At this speed, the round-trip mass ratio (fully fueled to burnout mass) would be about 34. This means that 33,000 tons of matter/antimatter fuel would be required, delivering a total energy equivalent to the electrical energy consumption of the entire United States for over 300,000 years!

Perhaps a more reasonable voyage might be a 10 light-year trip to the nearest, single, solar type star at a much slower speed in order to reduce the mass ratio penalty. At 0.2c the mass ratio for a round-trip voyage would be about two (fuel mass approximately equal to payload mass). Since this involves a much longer trip time (approximately 100 years), our spaceship would have to be much more massive, perhaps 10,000 tons or more, even if the life support was a closed system. The frontal area for a space ship of this mass might be as much as about 100 meters by 100 meters. In a 10 light-year distant round trip, this frontal area would carve out a volume in the interstellar medium equivalent to approximately twice the volume of the entire Earth.

What about the interstellar dust hazard? What might it be and how might we be able to protect ourselves? We know very little about the distribution and density of particulate matter in the interstellar medium except at the very small end, interstellar grains, as determined by the absorption of star light. It is interesting to note, however, that the density of these picogram particles in the interstellar medium is roughly equal to the density of these same size particles in the interplanetary medium near Earth. From a variety of ground-based and spaceborne measurements we now have a fairly good indication of the size distribution and space density of particulate matter in the interplanetary medium. Our Pioneer 10 and 11 missions to the outer solar system and beyond were the first and only spacecraft to carry micrometeorite detectors beyond the orbit of Mars. These detectors, sensitive to particles approximately a billionth of a gram and larger, indicated that the flux of these particles was not associated with the asteroid belt but instead was omnidirectional and independent of distance from the Sun out to 18 AU (Humes, 1980).

It is intriguing to consider the possibility that the size distribution and space density of particulate matter that we find in the interplanetary medium is the same as would be found in the interstellar medium. However, even if it were a order of magnitude lower in the interstellar medium, then the largest particle which we would have to contend with in our 10 light year round trip voyage would be about 100 grams (a large hail stone). At 0.2c, a 100 gram particle has a kinetic energy equivalent to the explosive energy of a 40 kiloton bomb!

Even neglecting hypervelocity impact ejecta and considering only the conversion of kinetic to thermal energy, a shield the equivalent of a 10 meter thickness of solid tungston would be required. Such a shield covering the front of our spaceship would weigh in excess of two million tons. Since the shield must be part of our payload (thus making our spacecraft weight rather insignificant by comparison), a mass ratio of two also requires a matter/antimatter fuel mass of two million tons. This is equivalent to 18 million years of U.S. electrical energy consumption, or about 90,000 times our present GNP.

The use of a cloud of dust particles injected upstream from a spaceship (Bond et al., 1978) has also been considered for shielding purposes. An inverted cone-shaped cloud with one microgram ice particle per cubic centimeter (a one microgram particle at 0.2c is equivalent to approximately 0.8 pounds of TNT) with a base diameter of one kilometer located 300 kilometers out in front of our spaceship would weigh about 86,000 tons, which is significantly less than our solid shield. However, this type of shielding would require long periods of no acceleration and in addition, would be subject to constant dissipation by external forces. By far the largest would be the forces generated by the constant impact of interstellar grains on the forward portion of the shielding dust cloud. For a one kilometer diameter ram area, this would be about 100 megawatts. This might require the equivalent of a complete replacement of the cloud every few weeks or at least every few months. For a 100 year journey, however, this cloud could not be replaced anymore frequently than about once every four years (which seems highly unlikely) in order to keep the total required mass for the dust cloud shielding less than that required by a solid shield.

5. CONCLUSIONS

The bottom line of all this is quite simply that interstellar travel is so enormously expensive and/or perhaps hazardous, that advanced civilizations do not engage in the practice because of the ease of information transfer via interstellar communication links.

They are not here, therefore they are either not there or they are there and they're all talking to one another.

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