The Space Congress® Proceedings

1991 (28th) Space Achievement: A Global Destiny

Apr 23rd, 2:00 PM - 5:00 PM

# Paper Session I-A - The Characteristics of Extraterrestrial Civilizations and the Interstellar Imperative

Joseph A. Angelo

*Director, Science Applications International Corporation, Melbourne, FL*

## The Characteristics of Extraterrestrial Civilizations and the Interstellar Imperative

by

Dr. Joseph A. Angelo, Jr.
Director-Advanced Technology, SAIC
700 South Babcock Street, Suite 300
Melbourne, FL 32901

**ABSTRACT**

The three major types of extraterrestrial civilizations that might evolve in the Galaxy are described, with speculative emphasis on each type of technical civilization's response to the **interstellar imperative**. A Type I civilization represents a planetary civilization; a Type II civilization involves a solar system society; while a Type III civilization is an interstellar community - ranging from a group of several star systems ("clustered" Type III) to a galaxy-wide community (fully-developed Type III). The important role of robotic interstellar probes in both Type II and Type III civilizations is also discussed.

### The Characteristics of Extraterrestrial Civilizations

According to some scientists, intelligent life in the Galaxy might be thought of as experiencing three basic levels or types of technical civilization, when considered on an astronomical scale. The Soviet astronomer, N.S. Kardashev (in examining the issue of information transmission by extraterrestrial civilizations in 1964), first postulated these three types of technologically developed civilizations on the basis of their energy use. **A TYPE I** civilization would represent a planetary civilization similar to the technology level found on Earth in the mid- to late- 20th Century. This Type I extraterrestrial civilization would command the use of somewhere between $10^{12}$ and $10^{16}$ watts of energy - the upper limit representing the amount of solar energy being intercepted by a "suitable" planet in its orbit about the parent star. For example, the solar energy flux at the Earth (i.e., the value of the solar constant outside the atmosphere) is approximately 1,370 watts per meter squared. A Type I civilization would experience the development of nuclear energy and spaceflight. A Type I civilization might even be gently stimulated by a primitive, but largely unappreciated, response to the **interstellar imperative**.

---

**Disclaimer**: The views expressed in this paper represent the personal views of the author and do not necessarily reflect the official opinions of the United States government or the Science Applications International Corporation (SAIC).

The dictionary defines "imperative" as a command or obligation. The **interstellar imperative** might, therefore, be defined as a deeply rooted, perhaps genetic, drive urging technically intelligent creatures to explore the unknown - initially across their home planet's surface, then out into their solar system, and ultimately across the interstellar void to neighboring star systems. As a Type I civilization begins to emerge from its home planet and expands out into the solar system around its parent star, this Type I civilization also transitions into the initial phases of a Type II civilization.

A **TYPE II** extraterrestrial civilization would engage in feats of planetary engineering, emerging from its home planet through advances in space technology and extending its resource base throughout the local star system. The eventual "energy use" upper limit of a Type II civilization might be taken as the creation of a **Dyson sphere**. A Dyson sphere is a postulated cluster of habitats and structures placed entirely around a star by an advanced civilization to intercept and use basically all the radiant energy from that parent star. What American physicist, Freeman J. Dyson, proposed in 1960 was that an advanced, intelligent extraterrestrial civilization would eventually develop the space technologies necessary to rearrange the raw materials of all the planets in its solar system, creating a more efficient composite ecosphere around the parent star. Dyson further postulated that such advanced civilizations might be detected by the presence of thermal infrared emissions from such an "enclosed star system", in contrast to the normally anticipated visible radiation. Once this level of extraterrestrial civilization is achieved, the search for additional resources and the pressures of continued growth could encourage interstellar migrations. This would mark the start of a Type III extraterrestrial civilization.

A **TYPE III** civilization would be an interstellar civilization consisting at first of several star systems and at maturity of a Galaxy-wide community of numerous intelligent species scattered over perhaps millions of star systems. In concept, a mature Type III civilization would be capable of harnessing the material and energy resources of an entire galaxy (typically containing some $10^{11}$ to $10^{12}$ stars). Using our Milky Way Galaxy as a model, a fully-developed Type III civilization would be capable of commanding energy levels of between $10^{37}$ and $10^{38}$ watts!

## Response to the Interstellar Imperative

But what can we now speculate about such advanced civilizations? Well, starting with the Earth as a model (our one and only "scientific" data point), we can at present somewhat confidently suggest that a Type I civilization might exhibit the following characteristics: (1) an understanding of the laws of physics; (2) a planetary society (possessing, for example, a global communication network and interdependent energy, food and material resource networks); (3) the intentional or unintentional emission of electromagnetic radiations (especially radio frequency); (4) the development of space technology and spaceflight - the technical tools needed to leave the home planet; (5) the development of nuclear energy technology, both for power supplies and weapons; and (6) (possibly) a desire to search for and communicate with other intelligent life-forms in the Universe. (**See Table 1**).

Many uncertainties are, of course, inherent in these speculations. Given the development of the technologies necessary for spaceflight, will a Type I planetary civilization make the demanding resource commitments to create a solar system (Type II) civilization? Do the planet's inhabitants develop the necessary long-range planning perspective that supports the eventual creation of artificial habitats and structures throughout their star system? Or do the majority of Type I civilizations unfortunately destroy themselves with their own advanced technologies before they can emerge from a planetary civilization into a more stable Type II civilization? Does the interstellar imperative encourage such creatures to go out from their comfortable, planetary "cradle" into an initially hostile, but resource-rich star system? If this "cosmic birthing" does not occur frequently, perhaps our Galaxy is indeed populated with intelligent life, but at a level of stagnant, isolated planetary (Type I) civilizations that have neither the technology nor the motivation to create a Type II extraterrestrial civilization or even to try to search for and communicate with any other intelligent life-forms across interstellar distances.

Assuming that a Type I civilization does, however, emerge from its home planet and create an interplanetary society, several additional characteristics might become evident. The construction of space habitats and structures, leading ultimately to a Dyson sphere around the parent star would represent a significant technical feat and could possibly be detected by thermal infrared emissions as incident starlight in the visible portion of the spectrum was intercepted, converted to other more useful forms of energy and the residual energy rejected to space as heat at perhaps 300 degrees Kelvin. (A thermal infrared source some one to two astronomical units in diameter might be the signature of a mature Dyson sphere.) Type II civilizations might also decide to search in earnest for other forms of intelligent life beyond their star system. They would probably use portions of the electromagnetic spectrum (radio frequency and perhaps X rays or gamma rays) as information carriers between the stars. Remembering that mature Type II civilizations would control about $10^{12}$ times as much energy as Type I civilizations, such techniques as electromagnetic beacons or feats of astroengineering that yield characteristic X ray or gamma ray signatures may lie well within their technical capabilities. Assuming their understanding of the physical Universe is far more sophisticated than that of a Type I civilization, such Type II civilizations might also use gravity waves or other physical phenomena (perhaps unknown to us now) in their effort to communicate across vast interstellar distances.

Type II civilizations could also decide to make initial focused attempts at interstellar matter transfer. Fully automated robot interstellar probes might be sent forth on one-way scouting missions to nearby stars. Even if the mode of propulsion (e.g., nuclear fusion) enabled systems to achieve only a modest fraction (i.e., ten percent or 0.1 c) of the speed of light, Type II societies should have developed the much longer-term planning horizon and thinking perspective necessary to support such sophisticated, expensive and lengthy missions. The Type II civilization might also utilize a form of panspermia (the diffusion of spores or molecular life precursors through space or even the directed shipment of genetically-encoded microorganisms through the interstellar void), hoping that if such "seeds of life" encountered a suitable ecosphere in some neighboring or more distant star system, they would initiate the chain of life - perhaps leading ultimately to the replication of intelligent life itself (suitably tempered by local ecological conditions).

Finally, as the Dyson sphere was eventually completed, some of the inhabitants of a Type II civilization might respond personally to the interstellar imperative and undertake the first "peopled" interstellar missions away from their parent solar system. Complex nuclear-powered space habitats in the outer regions of their solar system might be converted into giant "space arks" and carry migratory portions of this civilization to neighboring star systems. But here, we must inquire about the anticipated lifetime of a Type II civilization. Do typical Type II civilizations last several millennia or longer? Such societal lifetimes appear necessary (at least by terrestrial standards) to engage in major feats of planetary engineering within a solar system and to embark on an ambitious program of interstellar exploration. It would appear from an extrapolation of contemporary terrestrial engineering practices and assuming the development of very sophisticated , perhaps self-replicating, robotic systems that a minimum of 500 to 1,000 years would be required for an advanced Type II civilization to complete a Dyson sphere and to seriously explore nearby interstellar regions (out to distances of about 10 light years). **(See Table 2)**

Throughout the entire Galaxy, if just one Type II civilization embarked on a successful interstellar migration program, then - at least in principle - it could eventually (in perhaps $10^6$ to $10^8$ years) sweep through the Galaxy in a "leapfrogging" wave of colonization, establishing a Type III civilization in its wake. This Type III civilization could eventually control the energy and material resources of up to $10^{12}$ stars - or the entire Galaxy. To maintain effective control of such a galactic community, information and matter transfer would have to be accomplished by faster-than-light (superluminal) techniques that can now only be politely speculated about as "exotic". (See **Table** 3) This extended Type III civilization would readily be evident, since it would be galactic in extent and easily recognizable (at least by Type II civilizations) by its incredible feats of astroengineering (the manipulation of entire star systems).

In all likelihood, our Galaxy does not appear to contain a Type III civilization at present; or else the Solar System is being ignored (perhaps intentionally being kept isolated - the "zoo hypothesis" as some have speculated); or maybe we are one of the very last regions to be "filled in".

## What If "c" Is Really The Limit

Based on our current understanding of physics (including Einstein's Special Theory of Relativity), it now appears extremely difficult and energy-intensive to send matter across the interstellar void; although information can be transmitted at optic velocity (i.e., the speed of light). It has been suggested that a Type II civilization might travel between star systems (typically 3 to 4 light years apart) at a potentially achievable "advanced technology" speed of perhaps 0.1 c (a tenth of the speed of light), thereby taking some 50 or so years (accounting for acceleration and deceleration times) to make a one-way flight to the "next" star system. This "leap-frogging" approach to interstellar travel (perhaps in giant space arks) might eventually result in the diffusion of advanced intelligence throughout our Galaxy in some 1,000,000 to 10,000,000 years.

But several interesting questions would remain unresolved concerning the transition of such a starfaring Type II civilization into a Type III civilization. For example, just how large a sphere of influence could the parent Type II civilization maintain, if it took about 50 years to send matter just one-way to the next star system? Contemporary speculations suggest that if Einstein's Law of Special Relativity remains universally valid, then perhaps a "matter transfer" sphere of some 10 light years radius and an "information transfer" sphere of some 100 or so light years radius will define the extent of a functioning Clustered **TYPE** III interstellar civilization. Descendents of such a clustered Type III civilization could certainly migrate beyond these spheres of influence (matter transport and information exchange) but would eventually lose active contact with the parent civilization and then simply form other clustered Type III civilizations of their own.

However, the formation of a highly-interactive galactic community a few hundred or a few thousand light years in extent now appears physically impossible under the matter transfer and information transmission restrictions imposed by the speed of light (c). Contact between more modest-sized clustered Type III civilizations could still occur through much delayed bursts of information and or perhaps thorough the use of advanced (possibly self-replicating) robotic interstellar probes which might carry the history of each clustered Type III civilization to other clustered Type III communities over a period of millennia.

According to some scientists, any intelligent civilization (Type II or clustered Type III) that wants to explore a portion of the Galaxy more than 100 light years from their parent star, would probably find it more efficient to use self-replicating robot probes. Such a robot probe would travel across the interstellar void (perhaps at 0.1 c) and eventually arrive at a nearby star system. This sophisticated robot probe would then enter the new star system, exploring it thoroughly and reporting its findings back to the home civilization. The self-replicating robot probe would also gather energy and material resources to refurbish itself and to make one or more copies of itself which would then be sent out to other, more distant star systems. Since each robot probe (original and replicated progeny) would eventually beam exploration results back to the parent civilization, this galactic exploration strategy could produce the largest amount of data about other star systems for a given period of exploration. Of course, once the "descendant" robot probes traveled a thousand or so light years out the exploration chain could be broken for several reasons. These include: (1) a breakdown in the self-replicating system or its machine progeny; (2) an encounter with an intelligent, but perhaps "hostile" civilization which did not wish its resources appropriated; (3) a physical loss of contact with the parent civilization; and (4) the demise or extinction of the parent civilization.

One interesting advantage of using such interstellar robot probes versus interstellar (radio) beacons in the search for other intelligent civilizations is the fact that these probes could also serve as "cosmic safety deposit boxes", carrying the cultural treasures of Type II and clustered Type III civilizations through the Galaxy long after the parent civilization has actually perished. For example, the gold-anodized records we "terrans" included on the **Voyager 1** and 2 spacecraft and the message plaques placed on the **Pioneer 10** and 11 spacecraft represent our first attempts at achieving a small degree of cultural immortality in the cosmos. In principle, starfaring self-replicating systems should be able to keep themselves running for a long time. It has been estimated by some scientists that there may exist at present only 10 percent of all alien civilizations that have ever lived in the Galaxy (i.e., the other 90 percent having perished). If such speculations are true, then statistically at least, nine out of every 10 robot star probes within the Galaxy might actually be the only surviving emissaries from long-dead Type II and clustered Type III civilizations.

## Closing Comments

It is certainly possible that the Galaxy contains other intelligent technical civilizations - that more or less resemble the general types previously described. The other perspective is **that we are indeed alone** or are now the most technically advanced civilization in our Galaxy! If this latter circumstance is true, then we should recognize that we now stand at the technological threshold of creating the first Type II civilization in the Galaxy, and if successful, we can then respond to the interstellar imperative by becoming the first "wave of intelligence" to sweep across the Galaxy and establish the Milky Way's first Type III (or at least clustered Type III) civilization. If the former speculation is true, our transition to a Type II civilization may represent the technical threshold for entry into an established galactic community. Either alternative is truly spectacular!

It is also interesting to observe that with the landing of human beings made on the Moon (July, 1969 to December, 1972), we have already made the initial transition from a Type I to a Type II civilization. This transition has progressed even further recently with the passage of the Pioneer **10** and **11** spacecraft and the **Voyager 1** and **2** spacecraft beyond the known (planetary) regions of the Solar System on their very long (and unfocused) interstellar voyages - voyages that represent our first, very modest attempts at interstellar matter transfer. Spaceflight represents humanity's technical response to the interstellar imperative. In fully responding to this imperative over the next millennium, is it our species' cosmic destiny to create the Galaxy's first successful Type III civilization?

References

Joseph A. Angelo, Jr., **The Extraterrestrial** Encyclopedia (2nd Edition), Facts On File, Inc., New York, 1991.

Ben R. Finney and Eric M. Jones (editors), **Interstellar Migration and the Human Experience**, University of California Press, Berkeley, 1985.

**TABLE 1. Characteristics of a TYPE I Extraterrestrial Civilization.**

Main Characteristics

- Planetary Society
- Developed Technology
  - -- Laws of Physics
  - -- Space Technology
  - -- Nuclear Technology
  - -- Electromagnetic Communications
- Initiation of Spaceflight
  - -- Interplanetary
  - -- Permanent Space Bases
- Energy Resources: $10^{12}$ to $10^{16}$ watts

Response to Interstellar Imperative

- Unintentional or Intentional Electromagnetic Emissions (especially radio wave)
- Primitive, Unfocused Attempts At Interstellar Matter Transfer (e.g., Voyager 1 and 2 type probes)
- Early Attempts To Search for Intelligent Alien Life (especially passive SETI)
- Starting To Push Planetary Resource Limits (stimulus for off-planet expansion)

**TABLE 2. Characteristics of a TYPE II Extraterrestrial Civilization.**

Main Characteristics

- Solar System Society
- Construction of Space Habitats (with Dyson Sphere as limit)
- Long Societal Lifetimes (1,000 to 100,000 years)
- Ability to Perform Long-Term Planning (1,000 year horizons)
- Possible Interstellar Communication Between Type II Societies
- Energy Resources: $10^{26}$ to $10^{27}$ watts

Response to Interstellar Imperative

- Intentional Search for Intelligent Life Elsewhere in Universe (passive and active SETI)
- Interstellar Information Transmission (at $v = c$)
  - -- EM Beacons (radio wave, X-ray, gamma rays)
  - -- Advanced Techniques (gravity waves, ???)
- Interstellar Mass Transfer (initial attempts)
  - -- Robotic Probes ($v < 0.1c$)
  - -- Panspermia
  - -- Interstellar Arks ($v < 0.1c$)
- Ultimately All Radiant Energy of Parent Star Utilized (stimulus for interstellar migration)

**TABLE 3. Characteristics of a TYPE III Extraterrestrial Civilization.**

Main Characteristics

- Interstellar Society (either several star systems or ultimately galactic in extent)
- Interstellar Communication and Travel
- Magnificent Feats of Astroengineering (star system manipulation)
- Very Long Societal Lifetimes (1,000,000 years and more)
- Effectively "Immortal" for Planning Purposes
- Energy Resources: $10^{37}$ to $10^{38}$ watts (galactic output)

Response to Interstellar Imperative

If superluminal mass and information transfer possible, then **exotic** techniques used to bind galactic society:

- Communication:
  - -- neutrinos
  - -- tachyons
  - -- telepathy
  - -- ???
- Mass Transfer/Travel:
  - -- tunneling through black holes
  - -- space/time manipulation
  - -- ???

If "c" is the real limit for information and mass transfer, then

- Information Transfer Spheres of Influence about 200 light-years in diameter
- Mass Transfer Spheres of Influence about 20 light-years in diameter
- Self-Replicating Interstellar Robot Probes used to "communicate" through time between clustered Type III civilizations