A LOOK INTO THE FUTURE

Michael D. Papagiannis
Department of Astronomy
Boston University
Boston, Massachusetts 02215, USA

ABSTRACT. The quest for extraterrestrial life and for other stellar civilizations has finally become an international scientific endeavor. As our technology advances and major astronomical observatories are established in space, we will be able to gain a better understanding of ourselves and the Cosmos.

1. GAINS ACHIEVED IN THE LAST 25 YEARS

Tremendous strides have been made in the last 25 years in the search for life in the Universe. The advent of the space era with the launching of Sputnik on October 4, 1957, allowed us to place the first human being in Space (Yuri Gagarin, April 12, 1961), and to land the first astronaut on the Moon (Neil Armstrong, July 20, 1969). We began the exploration of the Solar System bringing lunar rocks back to Earth, landing several probes on Venus (the Venera proves), analyzing the soil of Mars for any evidence of life (Viking landers), and obtaining excellent data on Jupiter and Saturn and their many exciting moons, Io, Europa, Titan, etc. The last one, by the way, with its nitrogen and methane atmosphere seems to be an excellent and accessible cosmic laboratory for the study of chemical evolution, which in the case of the Earth led to life. Great progress is also being made in the study of the origin of life, where an international society (ISSOL) was established in 1970 and now has become a very active organization with more than 300 members.

The search for extraterrestrial intelligence has also become an established scientific task. After the call to action by Cocconi and Morrison in 1959 and the first search by Drake in 1960, SETI has grown with increasing speed and it is now an international endeavor with special commissions in the IAU, in the IAF, and in COSPAR. It has grown from a few, short searching periods at the hydrogen frequency, to the present SETI dedicated facilities and the capability to search over a wide range of the frequency spectrum with the new mega-channel spectrum analyzers soon to come into the scene. An exciting period is ahead of us with the implementation of NASA's comprehensive SETI program in the last decade of this century.

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Progress has also been made in the search for other planetary systems, where more discoveries are expected with the placing in orbit of the Space Telescope in 1986, as well as in our efforts to understand the early evolution of the Earth and its linkage to the appearance and early evolution of life on our planet. We are also beginning to recognize that the search for life in the Universe is an interdisciplinary activity where the input of geophysicists, chemists, paleontologists, biologists, and others is of great importance. This became quite clear in several interdisciplinary sessions of our our Symposium and it is steadily gaining ground with the closer collaboration of several international organizations, such as the IAU, IAF/IAA, ISSOL, COSPAR, IUBS, and others, that represent their respective disciplines in the common ground of "Life in the Universe." One can almost say that we have finally set all our forces into place and we are getting ready for a coordinated assault from many fronts on this fundamental problem "How did life originate and how common is it in the Universe, especially at the level of advanced civilizations."

2. EXPECTATIONS IN THE NEAR FUTURE

In the next 25 years we will probably gain a much better understanding on the abundance of planetary systems around other stars. The Allegheny Observatory of the University of Pittsburgh with its electronic astrometric photometer and its significantly improved astrometric telescope is ready to begin a systematic search for Jupiter-like planets in 100-200 nearby stars. Several other instruments for planetary detection are also in the development stage, and the Space Telescope will soon be in orbit. More sophisticated space infrared telescopes are also now in the planning stages with expected launching dates in the mid 90's. I believe that by the turn of the century we will know much more about planetary systems around other stars.

We will have also completed the first phase of the bimodal (targeted and all-sky) search of the NASA SETI program and several other conventional and unconventional searches, and we would have either found some other advanced civilizations, or we would be reassessing our theories. There might also be some progress in understanding the early development of our Solar System, especially with possible visits to asteroids, the Galileo mission to Jupiter, and conceivably with special missions to Titan or Europa. We will also know more in the area of chemical evolution and on the nature of the first self-replicating molecular systems.

3. THE TWENTY FIRST CENTURY AND BEYOND

A historical analysis shows that the ideas that prevailed during a given period on the kinds of searches to be undertaken or the means of communication with extraterrestrials to be used, simply reflected the then existing technology. Early in the 19th century, e.g., before the discovery of radio waves, the German astronomer and mathematician Carl

Friedriech Gauss was proposing to plant on Earth a colossal forest in the form of an orthogonal triangle to show to the extraterrestrial observers that our planet is inhabited by intelligent beings who know the Pythagorean Theorem. The lack of multichannel spectrum analyzers and the fact that the hydrogen line at 21 cm was the only known radio line in 1959, forced Cocconi and Morrison to propose to conduct the first search at the hydrogen frequency, which Frank Drake did in 1960. As more radio lines became known in the 1960's and the 1970's, such as the group of the four hydroxyl (OH) lines around 18 cm and the ammonia (NH_3) lines around 1.25 cm, searches were carried out at several other of these so called "magic frequencies". Finally with the current development of the new generation of mega-channel spectrum analyzers with 8 or more million channels, NASA is abandoning the magic frequency idea and is planning to cover a rather extensive frequency range in the 1 to 10 GHz interval.

It is rather clear that the kind of searches we might be conducting in the 21st century will again be a match to the available technology. If our a civilization will continue to avoid a nuclear holocaust, it seems quite likely that the next century will bring about the colonization of space. We will probably start with semi-permanent stations for military purposes, which unfortunately through history receive always priority treatment, to be followed by permanent scientific stations such as those we maintain in Antarctica, by materials processing plants on the Moon and in the asteroid belt, and toward the end of next century by permanent human settlements in space.

During this new space era of the 21st century, I can see the building of large telescopes and interferometers in space operating different regions of the electromagnetic spectrum, X-Rays, UV, Visible, IR and Radio. A Large Infra-Red Array (LIRA) on the Moon or in Space will probably be able not only to detect planets around nearby stars but also to obtain their infrared spectra in search of planets with a water signature, the most likely abodes of life. New generations of multichannel spectrum analyzers coupled with far more sophisticated data processing computers, will probably be analyzing the entire infrared and microwave spectral region for intelligent signals, including infrared laser pulses, which our future technology might recognize as a more effective means for interstellar communications.

By that time we would have also explored extensively our own Solar System and we would know much more about its origin, its early chemical evolution, and the prevalence of chemical processes that pave the path leading to life. We would have also searched throughout our Solar System for artifacts, including observing stations or relay stations, that would confirm the presence, present or past, of extraterrestrials in our Solar System. All these efforts will probably come naturally with the advancement of technology, the same way radio searches come naturally today with our present state of the art, and therefore they would not represent excessive or unreasonable expenditures of resources. By the end of the 21st century we will probably also know much more about the origin of life and the frequency and the evolution of planets with water. Hence, if we have not yet discovered any signs of other advanced civilizations in our Galaxy, we would be able to formulate a

more likely explanation for their absence and for the apparent uniqueness of our planet.

In summary, it appears that our civilization is approaching rapidly the advanced state of science and technology that will allow us to answer one of the most fundamental questions in Nature "How common is life, and especially advanced life, in the Universe?" Therefore, if we manage to avoid self-destruction, we will soon become communicants to the deepest mysteries of the Universe, ultimately understanding the significance of life and especially of life with cosmic consciousness in the Universe, probably the crowning achievement of the whole creation.

These are certainly some fantastic prospects for which it is worth leaving aside our insignificant little differences and conflicts to preserve our civilization, so that our descendants will be able to experience the supreme joy of becoming trustees of the ultimate knowledge of the Cosmos. It would be a terrible loss if after a tortuous marathon race of four billion years of biological evolution, to be so close to the end and blow it just a cosmic second before the victory line. Let us hope that we will show the needed wisdom to become partakers of this glorious cosmic future.