M87: A Bull's-eye For SETI?

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KEY WORDS: SETI, M87, Postbiological Universe

ABSTRACT

Postbiological life might operate (communicate, organize, travel, colonize) on a larger scale than a single galaxy—possibly on the scale of the supercluster. The most advanced postbiological civilizations in our Local Supercluster may have developed in the Virgo Cluster, a rich cluster where intergalactic communication and travel would be easiest. If these advanced civilizations wanted to contact new civilizations elsewhere in the Supercluster they might collectively broadcast from one central location, for the sake of efficiency and to make it easy to find. A powerful, centrally located beacon would tend to replace all others in the Supercluster. *This could explain the failure of SETI.* The most likely location for this beacon is the giant elliptical galaxy M87.

INTRODUCTION

The assumptions of conventional SETI have been spelled out by David Blair and rule out "Any scenario that involves enormous extrapolation of know technology"[1,2]. Conventional SETI search strategies concentrate on nearby stars, looking for civilizations not too different from ours—just somewhat more advanced. But Steven Dick, in a recent article in the *International Journal of Astrobiology*[3], calls for a "sweeping reconsideration of SETI assumptions and strategies" based on the probability that we live in a "postbiological universe—one in which most intelligence has evolved beyond flesh and blood to artificial intelligence (AI)." In Dick's view, postbiological life will be have "immortality, increased tolerance to their environment, capacity for action on a large scale and an intelligence far superior to our own," all of which should suit it well to space travel—interstellar or even intergalactic. Postbiological life, as Dick envisions it, might well operate (communicate, organize, travel, colonize) on a much larger stage than a single galaxy.

The Milky Way is a member of a small irregular cluster of two dozen galaxies known as the Local Group, spanning a few million light years, which in turn belongs to a much larger, disk-shaped collection of galaxies and clusters (totaling perhaps thirty thousands galaxies) known as the Local Supercluster, with a radius of 75 million light years. The center of our Supercluster is dominated by the Virgo Cluster, the largest cluster in the Supercluster and the nearest "rich" cluster to Earth, containing about 2500 galaxies (including 120 spiral galaxies) with a radius of 5 million light years. Our Local Group is about 50 million light years from the Virgo Cluster. The Local Supercluster might be a suitably large stage for a postbiological civilization.

A centralized supercivilization

When the first technological civilizations arose in our Supercluster, presumably billions of years ago[4], they, like us, would search for signals from other civilizations, first focusing on their own galaxy. But if technological civilizations were rare[5], they might have to wait many millions (maybe billions) of years before another civilization arose in their own galaxy, which means they would look to other galaxies. Eventually one would broadcast, two would make contact and communicate, then many.... We might suppose that this process would happen fastest near the center of the Supercluster, especially in the Virgo Cluster, where thousands of galaxies are concentrated. Over hundreds of millions of years these civilizations might combine their technologies and cultures to form a collection of very advanced civilizations (a supercivilization)—at least in the Virgo Cluster. This process might be similar to the way civilizations developed on Earth, as explained by Jared Diamond in *Guns, Germs, and Steel*[6]. The first civilizations arose in Eurasia—the largest land mass on Earth—where the diffusion of ideas and inventions among many cultures could most readily take place. Europe inherited and built on this head start to developed a massive technological lead which allowed them to colonize the rest of the world. The same process happened on a smaller scale in Polynesia, where Hawaii—the largest tropical Polynesian archipelago—developed the most complex technology and social organization. Diamond's basic principle is this: the most advanced civilizations will develop on the largest land masses (or collection of land masses, such as an archipelago, between which there is easy travel or communication.) This principle may be general enough to apply on a cosmic scale. *The Virgo Cluster may be the Eurasia of the Supercluster and possess a massive technological lead over the rest of the Supercluster.*

A rich cluster like Virgo might not only favor intergalactic communication but also intergalactic travel

and colonization. When discussing communication we know the speed—the speed of light—but when discussing travel, the speed is much less certain. Hart[7], when estimating Galactic colonization times, used ten percent light speed, which means it would take 100 million years to traverse the Cluster. At a more leisurely one percent light speed it would take a billion years. It might be argued that multi-million year trips through the empty space between galaxies would be impractical even for postbiological life. But intergalactic space in the Virgo Cluster is not really that empty. It is now known that about 10 percent of the stars in the Virgo Cluster (as well as any planets that might accompany them) are intergalactic, flung out from galaxies during tidal encounters[8]. These would provide "stepping stones" between galaxies. Intergalactic travel and colonization throughout the rest of the Supercluster is another matter. Distances between galaxies are greater and there are no (or at least very few) intergalactic stars and planets. Therefore, intergalactic travel and colonization might well be confined to the Virgo Cluster, with the possible exception of travel and colonization within local groups and clusters.

One central beacon

In the pioneering NASA research report: *Project Cyclops, A Design Study of a system for Detecting Extraterrestrial Intelligent Life*[9], SETI search strategies were discussed: "Is there any particularly likely direction in which to search for beacons? In this connection, Joshua Lederberg (private communication) has made an interesting suggestion. In a way it is much like Cocconi and Morrison's suggestion to use the hydrogen line in the spectrum. Lederberg asks: Is there any single point in the galaxy that is unique—that might be a natural cynosure for all races in the galaxy wherever they may be? He suggests the galactic center is that point." Thirty years later, Prof. Philip Morrison[10] reiterates this strategy, suggesting that a "remote-controlled source" may have been placed at the center as a "unique target for all the Galaxy." Similarly, if the Virgo Cluster is inhabited by a postbiological supercivilization that wanted to make contact with new civilizations elsewhere in the Supercluster, they might collectively broadcast from a central galaxy to make the beacon easy to find—but also, one might suppose, for the sake of efficiency. Why have beacons in every major galaxy in the Cluster when one beacon in a central galaxy would suffice? Cooperation and coordination on a scale of millions of light years is hard for us to imagine, but may be well within the capabilities of postbiological life. Besides, competition might have the same result, with the central galaxy gaining a monopoly on the "beacon business" by virtue of its positional advantage. A powerful, sophisticated and easily located beacon (at the center of the Virgo Cluster) might, for the same reasons, tend to replace or pre-empt all other "contact beacons" in the Supercluster, especially since its message could include some sort of "contact protocol" (frequency, code, strength, timing…) by which civilizations could quickly and efficiently establish contact. *This could explain the failure of SETI!* A supercivilization might dominate the Supercluster and advertise its presence from a single location! (A rough analogy might be made with the way direct broadcast satellites are replacing terrestrial television transmitters. Hundreds of channels can be received by aiming a small dish at a single point in space 36,000 kilometers above the Earth, whereas it is difficult to pull in terrestrial stations only 100 kilometers away. Eventually terrestrial television broadcasting may cease completely, eclipsed by a higher level of technology.)

M87

At the center of the Virgo Cluster is the giant elliptical galaxy M87, having a luminosity four times that of the Milky Way, with a super-massive black hole of three billion solar masses (the largest measured black hole to date) ejecting a spectacular jet many thousands of light years long. "M87…is one of the most studied extragalactic objects in modern astronomical research"[11] and we can only assume the same would be true for extraterrestrial astronomers elsewhere in the Supercluster. If a supercivilization occupied the Virgo Cluster and M87 and wanted to advertise its existence, it probably would, if it possessed the necessary technology, transmit from near the center of M87 (at a safe distance from the black hole!) If this were not possible, they might transmit from somewhere along the *line of sight* between the center of M87 and the target galaxy—maybe from an array of transmitters in the peripheral regions of M87, or even from intergalactic stars. Because M87 is being intensely studied anyway, SETI might be piggybacked for the most part.

It could be argued that M87 may not support life because it may lack Earth-like planets. According to Ward and Brownlee[5]: "Elliptical galaxies are regions with little dust which apparently exhibit little new star formation. The majority of stars in elliptical galaxies are nearly as old as the universe. The abundance of heavy elements is low, and although asteroids and comets may occur, it is doubtful that there are full-sized planets." But M87 is a *giant* elliptical. Giant ellipticals are thought to have grown over billions of years by cannibalizing and merging with other galaxies, some of them probably rich in planets. William B. Sparks reports in "Extended Emission-Line Gas in M87"[12]: "...complex strands and loops of emitting material may be seen extending over many kiloparsec. The emitting gas is dusty at a level consistent with Galactic gas-to-dust ratios." And from later in the article: "...capture of a gas-rich, dusty companion…could explain the presence of the cold gas...." Granted, M87 probably has far fewer Earth-like planets than a large spiral galaxy like the Milky Way, and therefore intelligent life may not have arisen there, but it

still should provide ample raw materials for any postbiological life that colonizes it. Postbiolgical civilizations would probably be composed mainly of spacefaring machines capable of harvesting the raw materials they need from asteroids or comets and would not be dependent on Earth-like planets. Indeed, they might possess technologies we can scarcely imagine, such as advanced fusion reactors that, as a by-product of energy production, could transmute hydrogen and helium, obtained from gas giant planets or brown dwarf stars, into the heavy elements they need. A recent paper in *Science*[13] gives evidence that gas giant planets may have formed in abundance even in very low metal environments in the early universe. (Most species of life on Earth evolved in the tropics, but technological civilizations thrive in the temperate zones. Similarly, although intelligent life might arise only on Earth-like planets in large spiral galaxies, postbiological civilizations might reach their highest levels in giant ellipicals such as M87, which are the largest galaxies and can contain trillions of stars.)

In the final chapter of *Profiles of the Future*[14], Arthur C. Clarke speculates that the jet from M87 might be artificial and that it might be an attempt by "cosmic engineers" to "signal across intergalactic space." In the decades since *Profiles* was first published (in 1962) much more has been learned about M87: about the physics of the jet, the accretion disk that ejects it and the black hole that powers it. It now seems clear that the jet is a perfectly natural phenomenon. Yet it *is* a very unusual jet. "While many hundreds of extragalactic jets are known from their non-thermal radio emission, there are only a dozen or so with prominent optical emission. Of these few, M87 is by far the nearest, and is thus the 'Rosetta Stone' for optical jet studies"[15]. Clarke's alien engineers may have altered the jet to enhance its optical emissions. They may be subtly modulating the jet in intensity or spectral quality to send a message. They may be harnessing the gravitational energy of the supermassive black hole to power a beacon. These might be the subjects of future SETI investigations. But for now I will assume that the alien engineers are simply taking advantage of this extraordinary natural phenomenon at the very center of the Supercluster to attract attention to an artificial beacon of a more conventional type.

Beacon energy

If a beacon exists in M87, why hasn't it been found? According to Lemarchand[16]: "Full-sky surveys by the Harvard, Arecibo, Ohio and Buenos Aires SETI projects did not find any evidence of omnidirectional supercivilization transmissions at a distance of 22 megaparsecs (70 million light-years)." It may be that the signals are weak or periodic and a relatively lengthy examination (hours? days?) would be necessary. If the location of the beacon can be logically deduced, as is argued in this paper, then a lengthy examination of the target might be expected from us. Another possibility is that the signals are in the optical or infrared rather than the radio band. A number of SETI projects are now under way to detect nanosecond light pulses. Blair and Zadnik[2] are using a 61-cm telescope to look for "two or three photon events" in a nanosecond from nearby stars. Howard and Horowitz[17] are doing a similar search with a 1.5 meter telescope. But would an optical beacon in M87 require implausible amounts of energy to be detectable by the relatively small telescopes used in these projects? The beacon would need to deliver to each large spiral galaxy like the Milky Way, which has a face on area of ~10^{42} m^2, about ten photons per square meter per second—or ~10^{43} photons—to create one detectable nanosecond event per second anywhere in the galaxy. The power output of a typical star is ~10^{26} watts. 10^{26} watts equals ~2.5 X 10^{44} optical photons per second. So about 4 percent of the energy output of one average star, if directed toward the Milky Way in the form of optical photons, could be detected—or with the pulse rate reduced to one every 100 seconds, about .04 percent. That is an enormous amount of energy for us, but probably not for a postbiological supercivilization. One might suppose that such civilizations would routinely construct "Dyson Spheres" to harvest the energy of stars, which could be used to power beacons. Of course, larger telescopes could detect weaker signals. One hopes that eventually some of the largest optical telescopes in the world will be available for SETI, as has been the case in the radio band. A Keck-sized telescope with improved detectors might be 100 times more sensitive than a 1.5 meter telescope[18], reducing the beacon energy required to irradiate each large galaxy with a detectable pulse once every 100 second to .0004 percent the energy output of an average star. Or put another way: the energy output of one average star could easily irradiate every galaxy in the Supercluster with pulses detectable by a Keck-sized telescope.

Motives

An objection to intergalactic SETI appears in the recent SETI Institute publication, *SETI 2020*[18]: "…the power demands placed on the aliens may be less an objection than their incentive for such intergalactic broadcasts. As Barney Oliver remarked, 'What would be the motivation to beam Andromeda if it takes four million years for a reply…?'" One answer is that immortal postbiologicals would not be deterred by a wait of four million or even a hundred million years. But a better answer may be that they are motivated not so much by a wish to communicate as by a need to reproduce, which is an essential feature of all life on Earth and probably will be an essential feature of postbiological life. Broadcasting would probably be the fastest way for them to colonize remote regions of the Supercluster such as ours. An information-rich message from a postbiological civilization might contain "blueprints" for machines with artificial intelligence instructions for making *them*. By

aiding in their reproduction we would gain enormous benefits and could develop quickly into a postbiological civilization of our own.

CONCLUSION

By accepting Dick's vision of a postbiological universe and reconsidering conventional SETI assumptions and strategies we have arrived at the surprising conclusion that M87 is a promising SETI target and, moreover, may be the *only* location where signals will be found. Therefore, we should first eliminate M87 before we pursue more nebulous approaches. If we turn our most powerful instruments—such as a Keck-class telescope—on M87 and find nothing, we can just go back to what we were doing before without wasting a lot of time. In fact, looking for signals coming from random directions may actually be *dangerous*, as pointed out by Moravec in *Mind Children*[19]. We may intercept data that has been "dormant in multimillion-year trips between galaxies," but when received might highjack our civilization like a monster computer virus. It might be prudent to look first toward the center of the Supercluster where a high level of civilization is likely to reign and where we could receive reliable information about how to avoid the perils that might surround us.

The general history of SETI has been a movement outward, from speculations since ancient times about civilizations on the Moon and Mars, to recent attempts to detect radio transmissions from nearby stars. This may be the time for SETI to expand its horizons once again, beyond the Milky Way. The hardest part of refocusing SETI's attention on a point 50 million light years distant may be psychological. We are short-lived organisms. 50 million years is an eternity to us. But if we are to make contact, we may need to think on a cosmic scale.

ACKNOWLEDGMENT

I thank Assoc. Prof. M. G. Zadnik for help with the photon calculations.

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