Editor's Introduction to IRAS, Vega, and Intelligent Life in the Galaxy

By Jerry Pournelle, Editor

I've long been known as a space enthusiast, and several years ago I was invited to become a member of the Board of the L-S Society Promoting Space Development. In those days the name was shorter; it was just "The L-5 Society," and the old guard still refer to it that way. As the long form of the name implies, the L-5 Society is a "space advocacy" organization.

The short form is even more telling: the L-5 point, sometimes known as the fifth Lagrangian, is the point in the Moon's orbit 60 degrees behind Luna. Objects placed in orbit at that point tend to stay there. It was for some years thought that would be a good place to put the first space colony. The L-5 Society is definitely for space colonies, hence the name- although, alas, the L-5 point is no longer considered the optimum place to build one.

Space colonies are just that: artificial places to live in space. The concept has been around for a long time; the first mention I am aware of was by the Russian astro-dreamer Tsiolkovsky, who also said "Earth is the cradle of mankind, but we cannot stay in the cradle forever." One of the first detailed views of life in a space colony was Robert A. Heinlein's "Universe." An early nonfiction examination of the concept was written by Dandridge Cole. The first engineering analysis of space colony requirements was published by Princeton physics professor Gerard O'Neill, which is why space colonies are sometimes known as "O'Neill Colonies," although it would be as appropriate to call them "Cole Colonies" or even "Tsiolkovsky Colonies."

Heinlein's space colony was special: it wasn't just a colony. If you have a self-sufficient space colony and a means of propulsion, you have a star ship. It will take many generations to cross the vast distances between the stars, but given sufficient sources' of energy it ought to get there. Heinlein's "Universe" was such a ship, which travelled for so long that its inhabitants lost all record of a time when they had -lived on planets.

I have written elsewhere of mankind's hundred billion-year future; a future that is possible, but only if we are able to survive the death of our Sun. Space colonies are one key to that future; which is why I have worked hard for the L-5 Society, and once called L-5 "the advance planning department of the human race."

Alas, the politics of space advocacy are tricky and varied, and can be vicious.

In late 1983 IRAS (Infra-Red Astronomical Satellite) observed cold matter surrounding the star Vega. As it happened, I was at that time preparing the report of the fourth meeting of the Citizens Advisory Council on National Space Policy. Dr. Robert Bussard, "inventor" (possibly "describer" would be a better term) of the Bussard interstellar ramjet and former Director of Fusion Energy Research at Los Alamos National Laboratory, is a member of the Council; and we were in telephone contact about his contribution when I read about the IRAS discovery.

I asked Bob if he would do an article about IRAS and cold matter for the L-5 News.

"Sure. Technical on IRAS, or general and philosophical about implications?" he asked.

"General. Connect the discovery to the rest of the universe."

"Right. Next week be okay?"

I assured him he could take his time. In due course the paper arrived and I sent it off to the L-5 News editor. I thought no more about it until months later when I recalled I hadn't seen it. By that time the L-5 Society was racked with an internal power struggle that seemed to involve me; I solved my part of that by withdrawing from any management of Society affairs. Alas, that didn't really end the matter, and the article was rejected by L-5, which is their loss.

In this article Dr. Bussard presents a theory of the relationship of CroMagnon to Neanderthal man that is not highly regarded by most paleobiologists, and which I cannot myself accept. However, I find that some experts with better credentials than mine find his view possible if not convincing; and in any case that particular sentence is not necessary to the balance of Bussard's argument. Bob offered to excise it for the L-5 News; I thought it best to leave the article intact.

Herewith Robert Bussard on the significance of the IRAS discovery.

Life in the Galaxy

The IRAS (Infra-Red Astronomical Satellite) has observed cold mater around the star Vega. It seems likely that the galaxy is filled with planets around stars and that it is highly likely that intelligent life exists elsewhere than Earth.

By Dr. Robert W. Bussard, President,
Energy Resources Group, Inc.

The most generally accepted theory of planetary formation is based on the idea, first put forward by Kant and LaPlace, that cold gas, collected by gravitational forces in star formation, led to a rotating ellipsoidal-shaped gaseous nebula around the protostar. This nebular "pancake" heated as it contracted under gravity, speeded up as it contracted, and formed planets by accretion around mass/density concentrations found within the nebular matter. The planets so formed would, of course, be in Keplerian orbits around the star.

The planetary accretions nearest the star occur in a nebular region of small volume and mass, and at high temperatures relative to the volume and mass available for "sweeping out" the colder, denser matter .at great distances. Because of this, the innermost planets would be expected to be formed from the condensation of materials with high vaporization temperatures, such as rock and iron; thus the "terrestrial" planets. Conversely, the outermost planets would be formed by condensation and collection of low boiling point materials, such as methane, ammonia, hydrogen; thus the "Jovian" planets. The whole process of planetary accretion given the initial nebular conditions-is thought to require only a few tens of thousands to a few million years, once started.

Detailed analyses of this process have been carried out on large computers (on models of star formation) over a wide range of conditions believed plausible for starting the process.

These studies all showed the formation of multiple terrestrial planets near their stellar source, and multiple Jovian planets further out, sometimes with one or two Pluto-like planets still further, beyond the cold giants. Thus it has been shown that planetary formation is an almost automatic adjunct of stellar formation on the neo-LaPlacian model. If so, the key question as to the likelihood of other planets (we know there are other stars!) would be, "Is the neo-LaPlacian model correct; does stellar-formation really appear in this mode?"

At last we have the beginnings of an answer, from data obtained by the IRAS satellite. This space observatory is built to detect infrared radiation from radiating sources other than stars. It has recently reported the observation of an extended infrared-radiating mass of considerable extent surrounding the star Vega. By all analysis this seems to be a gaseous nebula ready for or in process of planetary formation around Vega. Other such bodies now seem probable. Of course, if the star is too hot its nebular envelope will be too tenuous and extended for planetary formation on the model of our solar system, while if too cold its planets will be formed small and close in. No matter; space is filled with F, G, and K type stars (we are G-type) of the general temperature range which allow formation of Earth-type planets somewhere in the nebular contraction/ condensation process.

What all this means is that we now have evidence of the existence of conditions elsewhere for the formation of planets around (nearly all)

stars, and thus reason to support speculation that the galaxy is filled with planet-bearing stellar systems. Taking 10^{11} stars as a reasonable estimate for the stellar population of our galaxy, and 1/10 as the fraction in the "right" spectral/temperature class for life-of-our-type (LOOT), we estimate 10^{10} planetary systems as possible. Suppose only 1/10 of these contain planets capable of supporting Earth-type life; then there will be only(!) 10^9 planets capable of supporting creatures like ourselves, or LOOT.[1]

The consequences of this now-nearly-validated estimate are truly staggering. If, as generally agreed, life evolved on Earth in ca. 10^9 years, Earth is ca. 4.6 x 10^9 years old, and our galaxy is 10-15 x 10^9 years old, then we Earthlings are very latecomers in galactic history and are quite likely *not* alone. In fact, a simple estimate suggests that *at least* 10^8 planets should be out there with our type of life abounding; and most of these should contain intelligent life far, far older than our own. For the size of our galaxy this gives an average distance between intelligent species of our type of about 100 light years. Of course, the stellar/planetary density is not uniform. It is concentrated towards the galactic center and lesser in the outer regions (where we live, far out in the Ophiucius arm), so mean inter-LOOT distances should vary accordingly.

If all this is so-as the new IRAS evidence gives us new reason to believe-then where are "they" and who are we? If they exist so thickly why do we not see them? This famous question, first posed by Enrico Fermi[2] can be answered only by several possibilities:

(1) The detailed genetic evolution of LOOT is so improbable, even with Earth-like conditions, that we are nearly the first in all the galaxy, or;

(2) Nearly all LOOT committed suicide upon reaching a state of control of sufficient planetary energy resources, so the LOOT lifetime is too short to allow galactic exploration or;

(3) Densely populous LOOT exists, but chooses to conceal itself from us, or;

(4) We are so far out in the galactic countryside that no one has bothered to look our way yet, or;

(5) Interstellar transport is forever impossible.

Let us examine each possibility, in inverse turn.

(5) Interstellar transport cannot be forever impossible simply because even we (new-born and illiterate on the galactic scale) already know how to go about it. Whether by interstellar ramjets, laser-driven sails, or anti-matter rockets (or their ducted ramjet versions) we already have enough physics and-soon[3]-enough technology to make star flight work; and we will go out as soon as we can build the requisite machinery.

(4) It is not hard to find us, nor would it take long - if they are there we should have been found long ago. Given star-flight by any of the above means it is easy to show that the rate of expansion into the galaxy from a LOOT source outbound for exploration and colonization will be at a rate of about (c/1000). That is, the sphere of LOOT-occupied planets will expand at about one-thousandth the speed of light, once started. Thus reaching us, even from the galactic center, would take only 10^8 years at most; a time quite small compared to the galactic age. We should have been found long, long ago.

---

[1] This apparent preoccupation with "life-of-our-type" or "-as-we-know-it" is not an example of anthropocentricity. It is simply that it seems fruitless to speculate on the imagined infinite array of life-form possibilities which we do not know and therefore can not assess.

[2] In 1955, after a dinner party at then Livermore Labs Director Herb York's house in Livermore.

[3] Within 100 years or so.

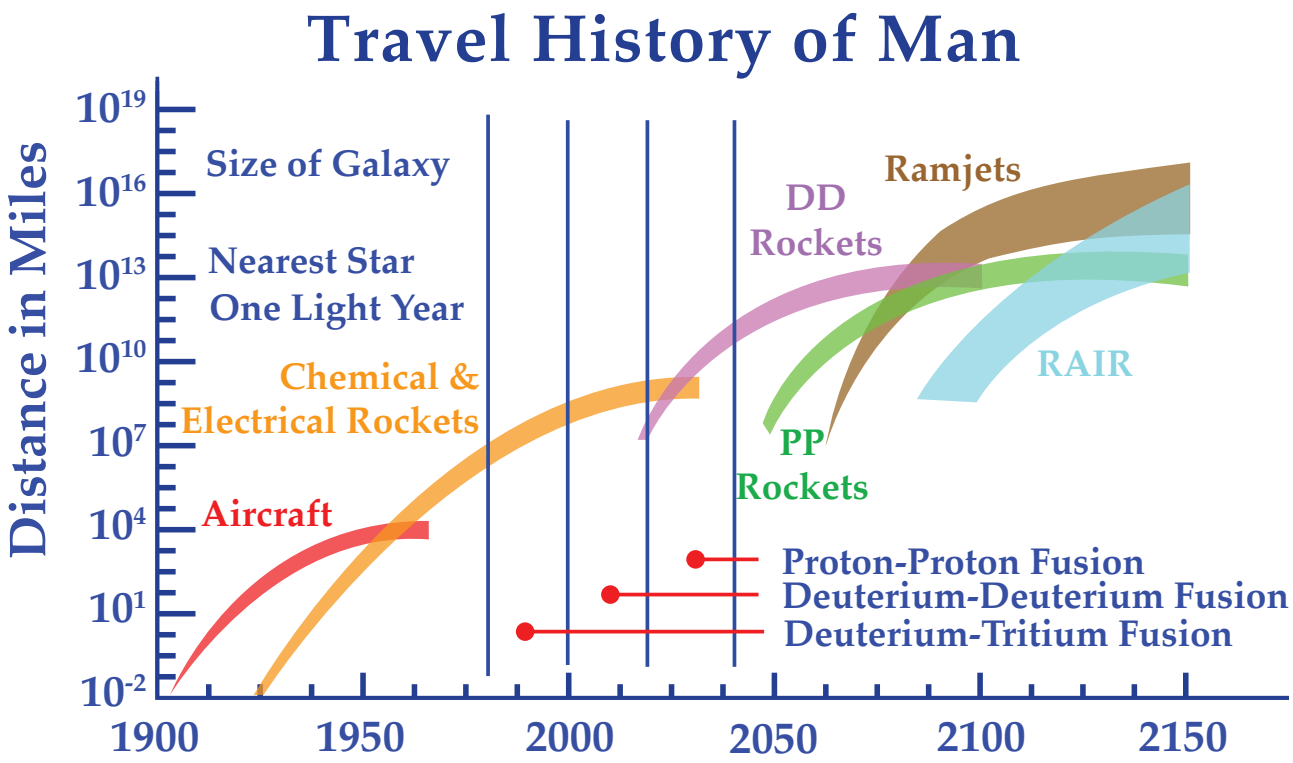
(3) Many reasons have been proposed for the unwillingness of an exploratory galactic colonization to show itself to us. Would we attempt to communicate with an island colony of destructive, semi-deranged, and apparently suicidal baboons carrying laser guns and using nuclear weapons? Better to let them find their own destiny. They settle down, stabilize, and find their way off their island in peace, then we talk; otherwise, we watch-and guard. Or perhaps there has not been any concealment at all. Perhaps quite the opposite; perhaps we are they. They landed here long ago by accident or design, descended into savagery in the corrosive atmosphere of Earth, which destroyed all ships, equipment, and non-sustainable technology, and became Cro-Magnon man, doing away with Earth's natural creature, Neanderthal. If so, our efforts at space flight are only the long echo of a lost dream of home.

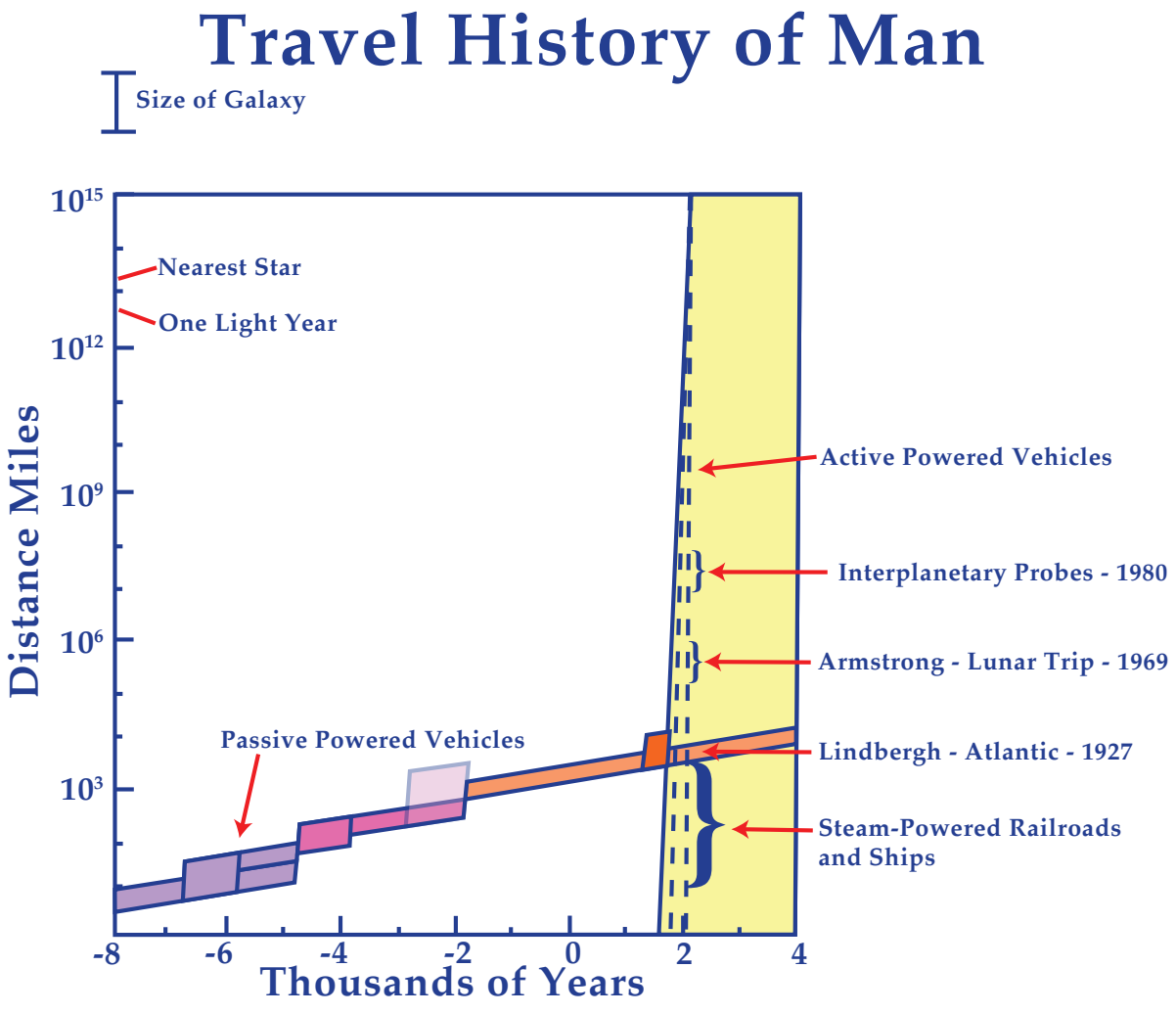
(2) Will we succeed in going out into the galactic darkness rich in new worlds suitable for us, or will we die before we go? Perhaps the nature of aggressive species which reach planetary dominance is such that the energy sources they control-which can make star flight possible-are used first among themselves in a pattern of destruction so complete that the race can never break out of its confining solar system shell. The bomb over Hiroshima gave us both the power to kill (nearly) all of ourselves or to escape to the stars. Which will we do? This is the preeminent issue of this most exciting of times.

Which did they do? Simple calculation shows that the probability of surviving this condition must be less than one part in a million, else the galaxy must be densely populated, and we may well be they. If so densely populated we should see them again, with a high frequency of contact. But do we (the UFO's?), or are they hiding (?), or did they all self-destruct?

(1) Or, finally, are we truly alone; the first intelligent species in the galaxy, the product of an immensely improbable chain of hundreds of thousands of sequentially coupled geological, chemical, biochemical, biological, and parallel astronomical events? Very simplistically, if 100 events of each type each had 10 possible outcomes only one of which was on the chain of success to life, the probability of success through the end of the event chain, over all the stars and the life of the galaxy would be only 10^{2} (1%). Ergo, we are the only intelligent planetary-energy-dominating handiwork of God in all the galaxy. But this is just a numbers game, and we all know what those are! Much more compelling is the data from our Mars and Venus probes. Both planets seem nearly (but not quite) able to support LOOT. They are each just a bit beyond the one-sigma point for people like ourselves. Thus we see within our own solar system a probability far higher than any version of the "numbers game" would give.

On balance it seems probable that life exists, that LOOT is out there, and that we will find it (if it does not signal us first) when we go out within 100 years or so. All we have to do is live without global nuclear war for this time, ours and our grandchildren's, and we will be saved-from ourselves — and will find again our fellows and our new/old galactic homes.


Travel History of Man
Distance in Miles
10^{19}
10^{16}
10^{13}
10^{10}
10^{7}
10^{4}
10^{1}
10^{-2}
Size of Galaxy
Nearest Star
One Light Year
Chemical &
Electrical Rockets
Aircraft
Ramjets
DD
Rockets
RAIR
PP
Rockets
Proton-Proton Fusion
Deuterium-Deuterium Fusion
Deuterium-Tritium Fusion
1900
1950
2000
2050
2100
2150


Travel History of Man
Size of Galaxy
Distance Miles
10^{15}
10^{12}
10^{9}
10^{6}
10^{3}
Nearest Star
One Light Year
Active Powered Vehicles
Interplanetary Probes - 1980
Armstrong - Lunar Trip - 1969
Lindbergh - Atlantic - 1927
Steam-Powered Railroads
and Ships
Passive Powered Vehicles
-8
-6
-4
-2
0
2
4
Thousands of Years

Travel History of Man