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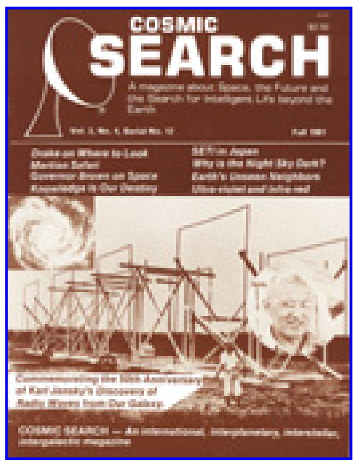

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The SEnTInel

By: Robert S. Dixon

Does Earth Have Unseen Neighbors?

Our current knowledge of nearby space is such that many unknown objects can and undoubtedly do exist in and near our solar system. They need only be small enough or distant enough to meet two criteria to have escaped detection:
1. Their long-range gravitational effects must be small, or we would detect their

effects on the motions of known objects, such as the planets.
2. Their reflected sun light must be dim, or we would detect them directly with optical telescopes.

These criteria are not very stringent, and they allow the existence of a multitude of interesting and unusual unknown objects in our neighborhood.

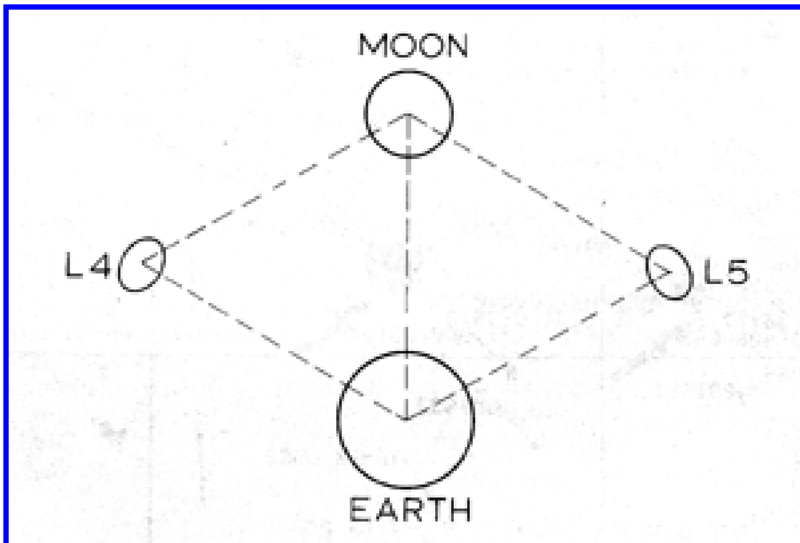
For example, alien spacecraft and ancient debris from the beginning of the solar system could exist undetected at Lunar distances or greater. Huge planets and even dim starlets could be unobtrusively circling the sun well beyond the orbit of Pluto. Certainly there are myriads of undiscovered small asteroids while our spacecraft continue to discover more planetary satellites, and new comets are found from time to time.

Searching for these unknown objects in our neighborhood is of considerable interest to many astronomers, and recently two unusual searches of this type have been announced. Each is separately described in the sections below:

I - A Search within the Earth-Moon System

There are two points in space within the Earth-Moon system that are referred to as stable equilbrium points. This means that if a small object were placed at one of those points, it would remain there indefinitely. If placed at any other point, the object would not remain stationary and could eventually fall onto the Earth or the Moon, or be thrown out of the system entirely. These two points are called the Lagrangian points L4 and L5, and they are located at the corners of equilateral triangles containing the Earth and Moon. They have been considered as good locations for Earth space colonies (hence the name of the organization "L5 Society"). They may also be good locations to park alien space probes; and they might harbor interesting ancient rocks and debris that could help us understand the origin of the solar system.

If the Earth and Moon were orbiting each other in isolation from the rest of the universe, the Lagrangian points would really be "points." However, the Sun's gravitational effects cause the "points" to be smeared out into small "ovals" that are approximately centered on the points. Objects will actually be stable only if they orbit around the Lagrangian points at the edges of the ovals. This situation is illustrated in the sketch. All the objects shown lie in the plane of the Moon's orbit around the Earth, and of course the entire system rotates as the Moon revolves around the Earth. As seen from Earth, stable objects in the L4 and L5 ovals would lead or follow the Moon at a nearby constant angle, but would move forward and backward slightly as they revolved around the center of their respective oval.



Earth, Moon and Lagrangian L4 and L5 points.

A number of searches have been made in these areas of space, using large, earth-based telescopes, high-flying aircraft and Skylab. The most detailed search thus far was made recently by Robert Freitas* (* Dr. Robert Freitas authored the article "The Cereal Box Syndrome" in the Summer 1981 issue of **Cosmic Search**.) of Santa Clara, California, and Francisco Valdes of the University of California at Berkeley, and their results were published in "Icarus" (volume 42, pp 442-447, 1980). They used the 30-inch telescope at Leuschner Observatory in Lafayette, California, to take 90 photographs which in total cover two 8° by 2° zones, surrounding both the L4 and L5 ovals. They employed a special tracking technique to follow the moving ovals as the photographs were being taken, and introduced an intentional "jog" into the telescope motion-halfway through the exposure to provide a double image of any object that might be discovered. The jog helps to discriminate against film defects, aircraft lights, and other effects that might cause false alarms.

To the limit of their sensitivity, they found no objects. Their limit is 14th magnitude, or equivalent to a Skylab-sized object. They consider their work thus far as being only preliminary, and recommend future searches with larger telescopes that could push the magnitude limit to 21, thereby enabling detection of objects as small as Pioneer 10.

The search of the Lagrangian points has only just begun. There are many more such points in the Solar System. For example, the Earth-Sun system has two such points, as does every other planet-Sun system. So does every other planet-satellite system (although some of the latter may be severely perturbed by the other satellites).

It would seem inescapable that sometime in the history of the Solar System some objects become trapped at the Lagrangian points. It will be interesting to ultimately find out what they are.

II - A Search Beyond Pluto

Objects whose mass is less than about 1/10 that of the Sun never generate enough heat to ignite their nuclear furnaces and become visible stars. These objects are called brown dwarfs, infrared stars, or low-temperature objects. As they form and contract out of the interstellar medium, they heat up and remain stable sources of infrared (heat) radiation for a long time, but eventually they cool off and solidify. During this contraction period, their apparent temperature depends on their mass. For example, an Earth-sized object would be about 30°K, a Jupiter-sized object about 100°K and an object on the borderline or becoming a star would be about 2000°K.

There may be several of these objects orbiting the Sun well beyond the orbit of Pluto, or just wandering through nearby interstellar space. They are not visible to normal telescopes because their reflected sunlight is too dim, and because they do not glow from their own light. They could only be detected with the special infrared telescopes that are now coming into operation. There are three infrared surveys of portions of the sky that have been or are now being conducted. These surveys are not necessarily searching specifically for new objects near the solar system, but nevertheless they may detect them along with other sources of infrared radiation. These surveys could and may detect an Earth-sized object at six times Pluto's orbital distance, a Jupiter-sized object at 19 times, and a borderline star at 70,000 times.

In 1982, the Infrared Astronomical Satellite (IRAS) is scheduled to fly, and it will significantly increase our capability to detect these objects. Ray Reynolds and Russell Waller of the NASA-Ames Research Center, and Jill Tarter of the University of California at Berkely recently summarized this entire situation and proposed using IRAS for this purpose. Their report appeared in "Icarus" (volume 44, pp. 772-779,1980). IRAS will be much more sensitive than the previous surveys, for objects ranging from somewhat larger than Earth (a Neptune-sized object could be detected out to 38 times Pluto's distance and a Jupiter-sized object to 400 times) up to those about half as massive as a borderline star (detectable at 11,000 times Pluto's distance). The Space Telescope could, in some size ranges, detect even more distant objects, but it is not suitable for survey-type observations.

The search for these objects has important implications for understanding the structure of the galaxy and the universe. If they are numerous they could collectively constitute a significant fraction of the mass of the universe, and yet have been hitherto invisible. Tarter calculates on the basis of such considerations that only one or two objects within the range of IRAS would be enough to profoundly change our understanding of these subjects.

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