THE LUNAR FARSIDE RADIO LAB STUDY OF THE IAA

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ABSTRACT. The “Lunar Farside Radio Lab” Study of the IAA, started in 1998 by late French astronomer Jean Heidmann (1923-2000), underwent substantial extensions and revisions since its coordination was taken up by this author. These modifications can be summarized as follows:

1) The goal of the Study was enlarged so as to encompass the whole of radio astronomy, rather than just SETI.
2) It was stressed that, from the Lunar Farside, one can detect radio frequencies lower than 15 MHz (i.e. wavelenghts longer than 20 m) impossible to detect from the Earth because of the blocking effect of the Earth’s ionosphere. By detecting these radio waves from the Farside onf the Moon, new discoveries should be expected especially in the fields of Cosmology and Stellar Astrophysics.
3) Lunar Farside Crater Saha, initially selected by Heidmann to host a radiotelescope, was replaced by Lunar Farside Crater Daedalus, located just at the Earth’s Antipode on the Moon Farside. In fact, Daedalus is much more shielded than “Saha” not only against the radiation emitted by any future spacecraft orbiting the Earth at distances higher than the geostationary orbit, but even against the radiation emitted by the future Space Stations located at the triangular Lagrangian points L4 and L5 of the Earth-Moon system, as proposed decades ago by Jerry O’Neill of Princeton University.
4) Four different scenarios were envisaged for the relevant space mission, dubbed RadioMoon:
   a) Cheapest and easiest of all, just let a spacecraft orbit the Moon in its equatorial plane and carry a 3-meter inflatable antenna detecting radio signals from the Universe when in the Shadow of the Earth, and downloading the data when above the Nearside.
   b) More expensive but not-so-hard-to-make: just the same as at a) but with two or more spacecrafts, so as to create and interferometric Array in orbit around the Moon.
   c) More expensive still and hard-to-make: landing a Phased Array inside Daedalus and keeping the link with the Earth by a relay satellite in circular orbit around the Moon.
   d) Very expensive and difficult: the same as at b) but with the goal of creating an Array of Phased Arrays inside Daedalus. Much robotic work would then be requested plus one or more relay satellites orbiting the Moon.

Finally, legal protection of Daedalus from radio-pollution would have to be sought, initially by virtue of the IISL.

The “Lunar Farside Radio Lab” Study of the IAA should be completed by October 2003 with a number of distinguished contributions. Its current status and future prospects are explained and justified in this paper.

1. Historical Introduction: Jean Heidmann’s 1994 Proposal for a SETI Base in the Farside Saha Crater

Radioastronomical and bioastronomical signals currentlly searched for by radio-astronomers fall into two classes:

1) Radio signatures of prebiotic and biotic molecules, important to the development of life, like the 22 GHz water maser.
2) SETI (= Search for Extraterrestrial Intelligence) signals that are presumably narrowband, but possibly wideband. The signals are expected to be broadcast by unknown ET civilizations in the Galaxy.

In order to detect signals of either types it is mandatory to reject all RFI (Radio Frequency Interference). Unfortunately, RFI is produced in ever increasing amounts by the growth of technological civilization on Earth, and has now reached a point where large bands of the spectrum are blinded by legal or illegal transmitters of all kinds.

Since 1994, the late French radio-astronomer Jean Heidmann had pointed out (see refs. [1], [2], [3]) that Radioastronomy from the surface of the Earth is doomed to die in a few decades if uncontrolled growth of RFI continues. Heidmann made it clear, however, that advances in modern space technology could bring Radio-astronomy to a new life, was Radioastronomy done from the Farside of the Moon, obviously shielded by the Moon spherical body from all RFI produced on Earth. Heidmann proposed that a radiotelescope should be placed inside the "Saha" Moon Farside crater, a ~ 100 km crater located in between longitudes 101° E and 105° E and 2° of latitude South, surrounded by a 3000 m high circular rim. Additionally, an Earth-pointing antenna should have been located in the Nearside Mare Smythii plain, linked to Saha "conveniently". Since 1994, this and other authors studied with details the link between Saha and Mare Smythii, and suggested it to be made by either optical fibers (plus a "tether" for the descent-on-the-Moon maneuver) or by a few relay stations to be landed on the Moon surface. The relevant space mission, however, is hard to design at a low cost (ref. [4]).

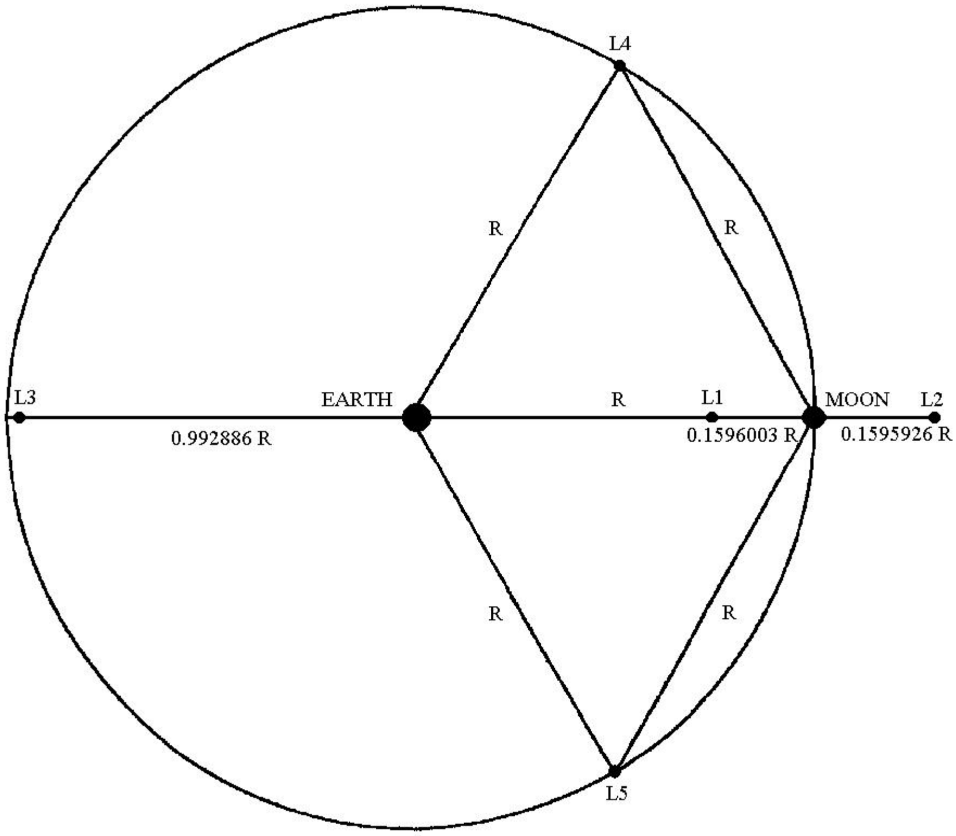

Figure 1: Locations of the five Earth-Moon Lagrangian points, namely where the Earth and Moon gravitational forces upon a spacecraft cancel out:

1) **Let *R* denote the (mean) Earth-Moon distance, that is 384,400 km. Then, the distance between the Moon and the Lagrangian point L1 equals 0.1596003*R, that is 61350 km. Consequently the Earth-to-L1 distance equals 0.8403997*R, that is 323050 km.**
2) **The distance between the Moon and the Lagrangian point L2 equals 0.1595926*R, that is 61347 km.**
3) **The distance between the Earth and the Lagrangian point L3 equals 0.992886*R, that is 381666 km.**
4) **The two "triangular" Lagrangian Points L4 and L5 are just at same distance *R* from Earth and Moon.**

2. Terminal Longitude λ on the Moon Farside for Radio Waves emitted by Telecommunication Satellites in orbit around the Earth

In this section we provide an important mathematical formula, vital to select any RFI-free Moon Farside Base.

We want to compute the (small) angle α beyond the limb (the limb is the meridian having longitude 90° E on the Moon) where the radio waves coming from telecommunications satellites in circular orbit around the Earth still reach, i.e. they become tangent to the Moon's spherical body. The new angle $\lambda = \alpha + 90°$ we shall call "terminal longitude" of these radio waves. In practice, no radio wave from telecom satellites can hit the Moon surface at longitudes higher than this terminal longitude λ.

The proof of this theorem was recently published by this author in ref. [7], page 194, and will not be repeated here. The important result is following formula for the terminal longitude λ of radio waves on the Moon Farside (between 90° E and 180° E) emitted by a telecom satellite circling around the Earth at a distance R:

$$\lambda = \operatorname{atan}\left(\frac{R - R_{Moon}}{\sqrt{D^2_{Earth-Moon} - (R - R_{Moon})^2}}\right) + \frac{\pi}{2} .$$

Here the independent variable R ranges only between 0 and the largest value making the above radical still positive, so the range is $0 \le R \le D_{Earth-Moon} + R_{Moon}$. The equation above for λ shows that the $\lambda(R)$ curve becomes vertical for $R \to (D_{Earth-Moon} + R_{Moon})$ and $\lambda = 180°$. Upon replacing for R the value of the geostationary radius, R = 42241.096 km, one finds for the Moon Farside terminal longitude λ the value $\lambda = 96.525°$. *This is how Heidmann came to select and propose crater Saha*: he just used the above (unpublished, but obvious) argument to compute that the longitude of the needed crater had to be higher than the value of 96.525°. Then, allowing a little more tolerance of about 5° in longitude for further shielding by the Moon's body, he finally declared in [1] that Saha was the "best" crater to establish a Lunar SETI base. For six years (1994-2000), no one thought of questioning Saha as "best" crater, but this author proposed in ref. [7] crater Daedalus as a much more shielded place than Saha.

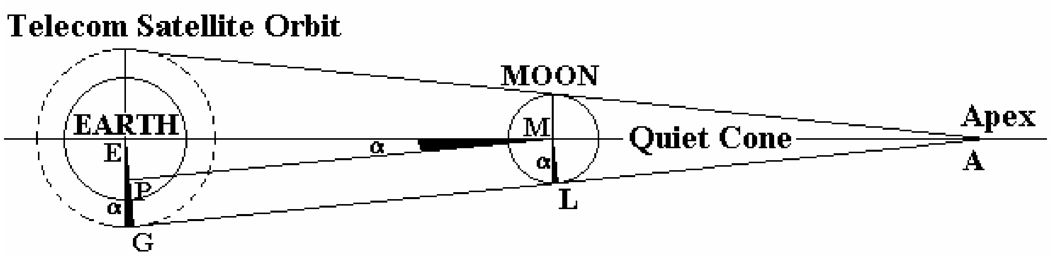

Figure 2. The simple geometry defining the "Terminal Longitude, λ" on the Farside of the Moon, where radio waves emitted by telecom sats circling the Earth at a radius *R* are grazing the Moon surface.

3. Selecting Crater Daedalus at 180° E

The author of this paper claims that Heidmann was too optimistic in excluding that telecommunications satellites will ever be put into orbits around the Earth ***higher than the geostationary orbit of 42241.096 km.***

In other words, this author claims that the time will come when commercial wars among the big industrial trusts running the telecommunications business by satellites will lead them to grab more and more space around the Earth, pushing their satellites into orbits with apogee much higher than the geostationary one, with the result that ***crater Saha will be blinded as soon as the first company decides to go higher than the geostationary orbit.*** The last remark is important to Bioastronomers. If we, the supporters of Bioastronomy, bet everything on a SETI and Bioastronomy Base located at Saha, then we may loose everything pretty soon! ***A "safer" crater must be selected further East along the Moon equator. How much further East?*** The answer if given by the diagram in Figure 3, based on the above equation for λ.

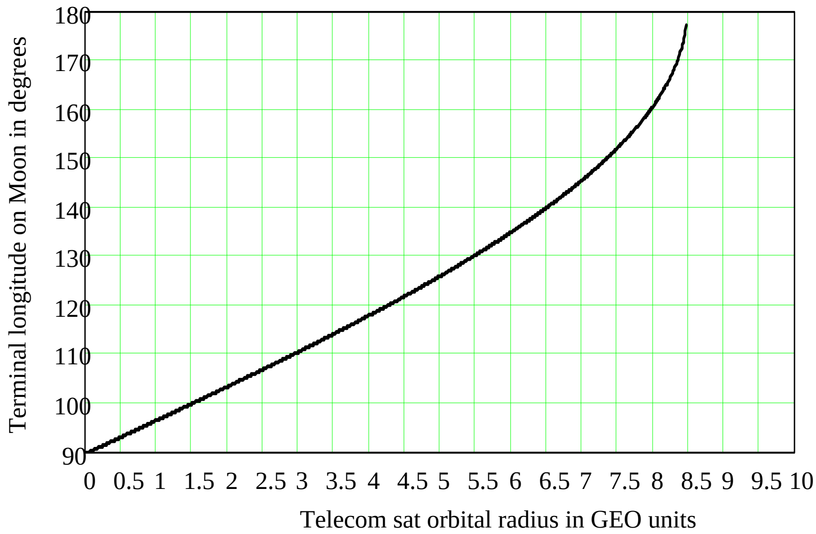

Figure 3.

Terminal longitude λ (vertical axis) on the Moon Farside versus the telecom sats orbital radius *R* around the Earth (horizontal axis), in units of the Earth's geostationary radius (42241.096 km).

The vertical trait predicted by our equation for λ shows up in Figure 3 as the "upgoing right branch". This shows that the largest distance from the Earth's center for telecom satellites is about 8.479 times the geostationary radius, corresponding to a circular orbital radius of 358148 km. Was a telecom satellite put in such a circular orbit around the Earth, its radio waves would reach Moon longitudes as high as about 175°. Furthermore, we did not consider any Lagrangian point yet! When we do, it turns out that it will never be possible to put a satellite into a circular orbit around the Earth at a distance higher than 358148 km, simply because this distance would lie beyond the distance of the Lagrangian point L1 nearest to the Earth, located at 323050 km. In conclusion, one is led to wonder: what is the Moon Farside terminal longitude corresponding to the distance of the nearest Lagrangian point, L1 ? The answer is given by upon replacing R = 323050 km in the equation for λ, resulting in $\lambda = 154.359°$. Translated into words, this means the following basic result: ***the Moon Farside Sector in between 154.359 E and 154.359 W will never be blinded by RFI coming from satellites orbiting the Earth alone.***

One more point now. Clearly, the ***limit*** of the terminal longitude λ as a function of the satellite's orbital radius R around the Earth, for R approaching infinity, ***is* 180°**. But 180° (where E and W longitudes coincide at a common meridian like the "change-of-date line" on Earth) is the ***antipode*** to Earth on the Moon surface, namely the point exactly opposite to the Earth direction on the other side of the Moon. Our theorem thus simply proves that the antipode is ***the most shielded point on the Moon surface from radio waves coming from the Earth. An intuitive and obvious result, really.***

At this point, it is pretty obvious where are we going to locate our Farside Moon base. Just take a map of the Farside and look. One notices that the antipode's region, at the crossing of the central meridian and of the top parallel in the figure, is a rugged region, too rugged to establish a Moon base. Fortunately, however, just about 5° South along the 180° meridian, one finds a large crater about 80 km in diameter. This crater is called Daedalus. So, ***this author proposes to establish the first RFI-free base on the Moon just inside crater Daedalus, the most shielded crater of all on the Moon from Earth-made radio pollution!***

A nice picture of crater Daedalus is shown in Figure 4. It was shot back in 1969 during the Apollo 11 mission that saw the first, historical landing of humans on the Moon. The picture reveals that crater Daedalus could well host an ***array*** of radiotelescope antennas. To make a start, however, just a single-antenna mission would prove the advantages of this site.

Figure 4.
AS11-44-6609 (July 1969) - An oblique of the Crater Daedalus on the Lunar Farside as seen from the Apollo 11 spacecraft in lunar orbit. The view looks southwest. Daedalus (formerly referred to as I.A.U. Crater No. 308) is located at 179 degrees east longitude and 5.5 degrees south latitude. Daedalus has a diameter of about 50 statute miles (~ 80 km). This is a typical scene showing the rugged terrain on the Farside of the Moon, downloaded from the web site: http://spaceflight.nasa.gov/gallery/images/apollo/apollo11/html/as11_44_6609.html

4. This author's vision of the entire Moon Farside for RFI-free Searches:

Having selected crater Daedalus as location for our future Moon Farside Base, we now wish to achieve a vision of the entire Farside for its best future use.

To start, let us replace the exact value of λ=154.359° with the simpler value of λ=150°. We are lucky in that the value of λ=150° matches perfectly with the need for having the borders of the Pristine Sector making angles ***orthogonal*** to the directions of triangular Lagrangian points L4 and L5, which is where future space bases are expected to be constructed in the future.

The result of this "geografical partition of the Moon Farside" is this author's vision of the Farside of the Moon, depicted in Figure 5.

Some sort of international treatise(s) among the leading space-faring nations of the world might wish to "freeze" this partition into a sort of "Natural Preserve of Humankind". It could be called "The Radio-Quiet Preserve of Humankind", hopefully to be kept such in the centuries to come for the benefit of the whole of Humankind.

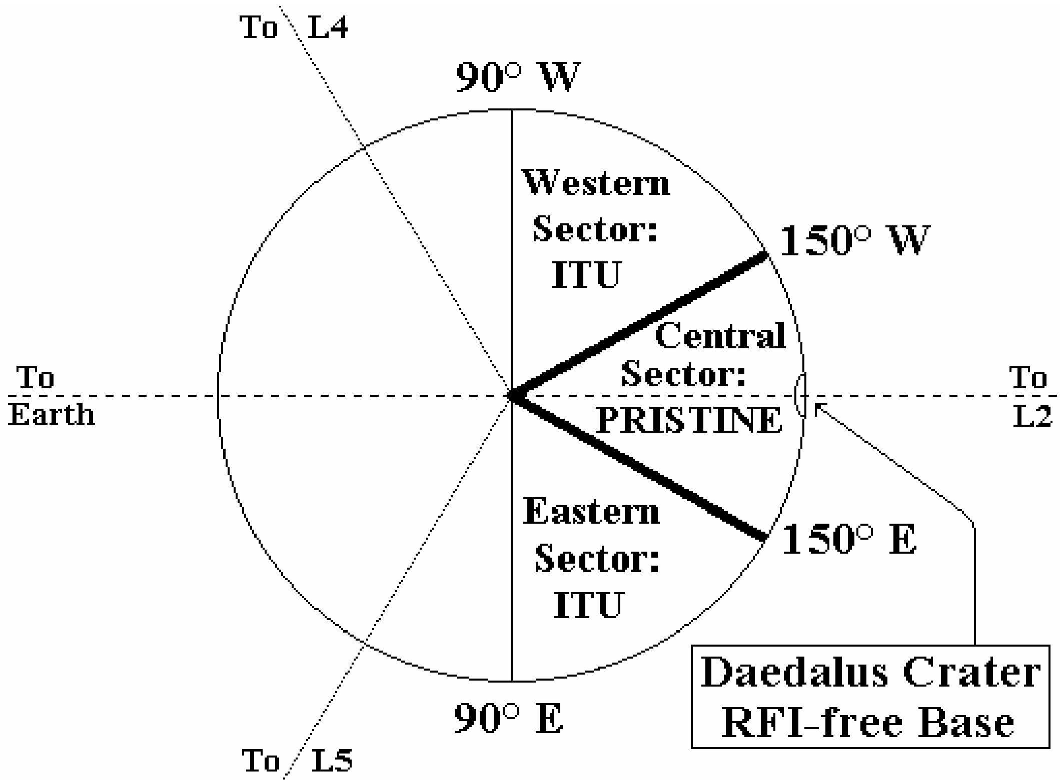

Figure 5.

This author's vision of the Moon Farside with the Daedalus Crater Base for RFI-free Bioastronomy, Radioastronomy, as well as SETI. In the future, even two International Space Stations (ISS) might be located at both the L4 and L5 Earth-Moon Points in the future. Only Point L2 will have to be kept free at all times. The Nearside would be "colonizable" freely.

Figure 5 shows a diagram of the Moon as seen from above its North Pole with the different "colonization regimes" proposed by this author. Please notice that:

1) The Nearside of the Moon is left totally free to activities of all kinds: scientific, commercial and industrial.
2) The Farside of the Moon is divided into three thirds, namely three sectors covering 60° in longitude each, out of which:
   a) The Eastern Sector, in between 90° E and 150° E, can be used for installation of radio devices, under the control of the International Telecommunications Union (ITU-regime).
   b) The Central Sector, in between 150° E and 150° W, must be kept totally free from human exploitation, namely it is kept in its "pristine" radio environment, free from man-made RFI. Right at the center of this Central Sector, i.e. very close to the Antipode of the Earth, is located crater Daedalus, an 80 km crater that we propose as the most RFI-shielded place for the Moon Farside Base.
   c) The Western Sector, in between 90° W and 150° W, can be used for installation of radio devices, again under the control of the International Telecommunications Union (ITU-regime). Also:
3) The Eastern Sector is exactly opposite to the direction of the Lagrangian point L4, and so the Moon's body completely shields the Eastern Sector from RFI produced at L4. Thus, L4 is fully "colonizable".
4) The Western Sector is exactly opposite to the direction of the Lagrangian point L5. The Moon's body thus shields the Western Sector from RFI produced at L5. Thus, L5 is fully "colonizable" in this author's vision, whereas it was not so in Heidmann's vision. In other words, this author's vision achieves the ***full bilateral simmetry*** of the vision itself around the plane passing through the Earth-Moon axis and orthogonal to the Moon's orbital plane.
5) Of course, L2 may not be utilized at all, since it faces crater Daedalus just at the latter's zenith. Any RFI-producing device located at L2 would flood the

whole of the Farside, and must be ruled out. L2, however, is the only Lagrangian point to be kept free, out of the five located in the Earth-Moon system. Finally, L2 is not directly visible from the Earth since shielded by the Moon's body, what calls for "leaving L2 alone"!

5. The Further Two Lagrangian Points L1 and L2 of the Sun-Earth System and their "polluting" action on the Farside of the Moon

There still is an unavoidable drawback, though. This is coming from the ***further two Lagrangian points L1 and L2 of the Sun-Earth system***, located along the Sun-Earth axis and outside the sphere of influence of the Earth, having a radius of 924646 km around the Earth. Precisely, the Sun-Earth L1 point is located at a distance of 1496557.035 km from the Earth towards the Sun, and the L2 point at the (nearly, but not exactly identical) distance of 1496557.034 km from the Earth in the direction away from the Sun. These two points have the "nice" property of moving around the Sun just with the same angular velocity as the Earth, while keeping also at the same distance from the Earth at all times. Thus, they are ***ideal places for scientific satellites***.

Actually, the Sun-Earth L1 Point has already been in use for scientific satellite location since the NASA ISEE III spacecraft was launched on 12 August 1978 and reached the Sun-Earth L1 in a month.

On December 2, 1995, the ESA-NASA "Soho" spececraft for the exploration of the Solar Corona was launched. On February 14, 1996, Soho was inserted into a halo orbit around the Sun-Earth L1 point, where it is still librating now (July 2002).

As for the Sun-Earth L2 point, there are plans to let the NASA's SIM (Space Interferometry Mission) satellite be placed there, as will probably be ESA's GAIA astrometric satellite as well.

All these satellites do "POLLUTE" the otherwise RFI-free Farside of the Moon when the Farside is facing them. Unfortunately, the Moon Farside is facing the Sun-Earth L1 point for half of the Moon's synodic period, about 14.75 days, and it is facing the Sun-Earth L2 point for the next 14.75 days. Really all the time!

This radio pullution of the Moon Farside by scientific satellites located at the Lagrangian Points L1 and L2 of the Sun-Earth system is, unfortunately, UNAVOIDABLE. We can only hope that telecom satellites will never be put there in the future. As for the scientific satellites already there or on the way, the radio frequencies they use are well known and usually narrow-band. This should enable the future Moon Farside spectrum analyzers to get rid of these transmissions completely.

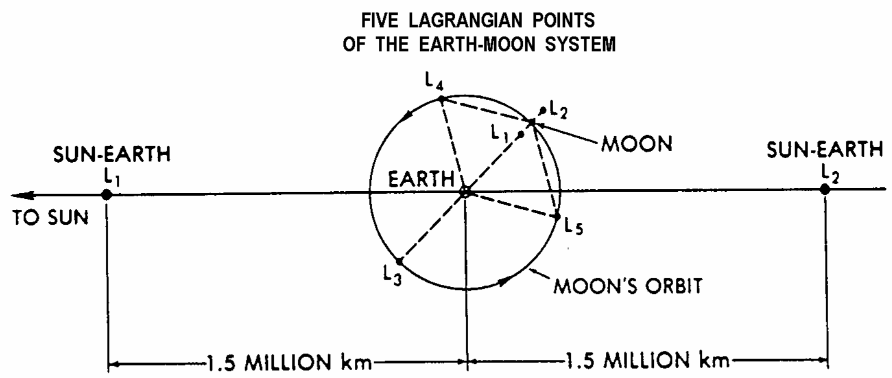

Figure 5.

In addition to the five Lagrangian Points of the Earth-Moon system (already described in Figure 1) the next two closest Lagrangian Points to the Earth are the Lagrangian Points L1 and L2 of the Sun-Earth system. These are located along the Sun-Earth axis at the distances of about 1.5 million kilometers from the Earth toward the Sun (L1) and outward (L2). Unfortunately, spacecrafts located in the neighbourhood of these L1 and L2 Sun-Earth Points do send electromagnetic waves to the Farside of the Moon. Examples are the ISEE-III and Soho spacecrafts, already orbiting around L1, and more spacecrafts will do so in the future around both L1 and L2.

6. The Quiet Cone above the Farside of the Moon

The spherical body of the Moon prevents all terrestrial electromagnetic waves from reaching the central part of the Farside, as described in the previous secions. But it does so also for a certain region of ***space*** above the Farside itself, that we have decided to call the "Quiet Cone" (see ref. [8]). This definition is appropriate inasmuch as clearly the radio waves tangent to the Moon body define a cone, and clearly the apex of such a cone is the closer to the Moon Farside the higher the radius R of the telecom sats around the Earth is. To calculate how far into space the quiet cone extends, consider Figure 2 again. The similarity between the rectangular triangles EGA and MLA (rectangular at G and L, respectively) immediately shows that (EM+MA) : EG = MA : ML, that is $\left(D_{Earth-Moon} + H_{Apex}\right)/R = H_{Apex}/R_{Moon}$.

Solving for H_{Apex} yields the height H_{Apex} of the apex of the quiet cone above the Moon farside with respect to center of the Moon:

$$H_{Apex}(R) = \frac{D_{Earth-Moon} \cdot R_{Moon}}{R - R_{Moon}}.$$

Two numerical cases of this equation are important:

1) ***For geostationary orbits of 42,241.096 km, the corresponding apex of the quiet cone is located at 16,496 km outward from the Moon center. In other words, this is how far the quiet cone extends into space nowadays, but pratically the actual value may be lower in the year 2002 already, for we don't know about military satellites.***
2) The lowest possible value of the apex height corresponds to a satellite circling the Earth at the maximum possible distance, namely at the distance of the Langrangian Point L1. Thus, ***the minimal value of the apex is 2,079 km***.

7. Proposing "RadioMoon": A New Space Mission to Set up an RFI-free Base inside Crater Daedalus

A problem is that it will hardly be possible to link the base at crater Daedalus to other bases on the Moon visible side by virtue of optical fibers or landed data relays, because of the large distance of 2730 km existing between Daedalus and anywhere along the limb.

To solve this problem, the proposal is made for a new space mission dubbed "RadioMoon" and briefly described in this section. RadioMoon is made up by two spacecrafts: one orbiter and one lander. They fly together from the Earth to the Moon and are initially parked in a Moon circular and equatorial orbit having a radius of, say, 10,000 km. The orbital period of this single spacecraft around the Moon is 31.641 hours (1.3 days). Then, at a time when the spacecraft is just crossing the Earth-Moon axis on the visible side, the lander is released from the orbiter and starts getting down towards the Moon surface along a Hohmann transfer half-elliptical trajectory. By the very definition of this Hohmann transfer, the lander just lands at the longitude of 180° E, namely inside crater Daedalus (slightly different manoeuvers there would slow down the spacecraft, to prevent it from crashing). The Hohmann transfer has these parametrs: semimajor axis 6378 km, eccentricity 0.742, time to get down from 10,000 km along the half-ellipse 6 h 52.86 m. The lander would be protected by airbags against crashing. We know that such airbags worked out well on July 4, 1997, for the Mars Pathfinder landing on Mars. Since the gravity on the Moon is about a half of the gravity on Mars, there is no reason to doubt that such an airbag-protected landing would work equally well on the surface of the Moon. Finally, after touching down, the lander deploys a flat phased array capable of steering its beam electronically for all RFI-free Searches in Radioastronomy, Bioastronomy and SETI. The orbiter's task is to gather data from the Phased Array at crater Daedalus when flying above the Farside, and transmit these data back to the Earth when flying above the near side. And the other way round for giving the Earth's instructions to the Phased Array operating at Daedalus, now dubbed the "Lunar Farside Radio Lab". We contend this is by far the cheaper, easier and safer way to operate a Moon Farside Base.

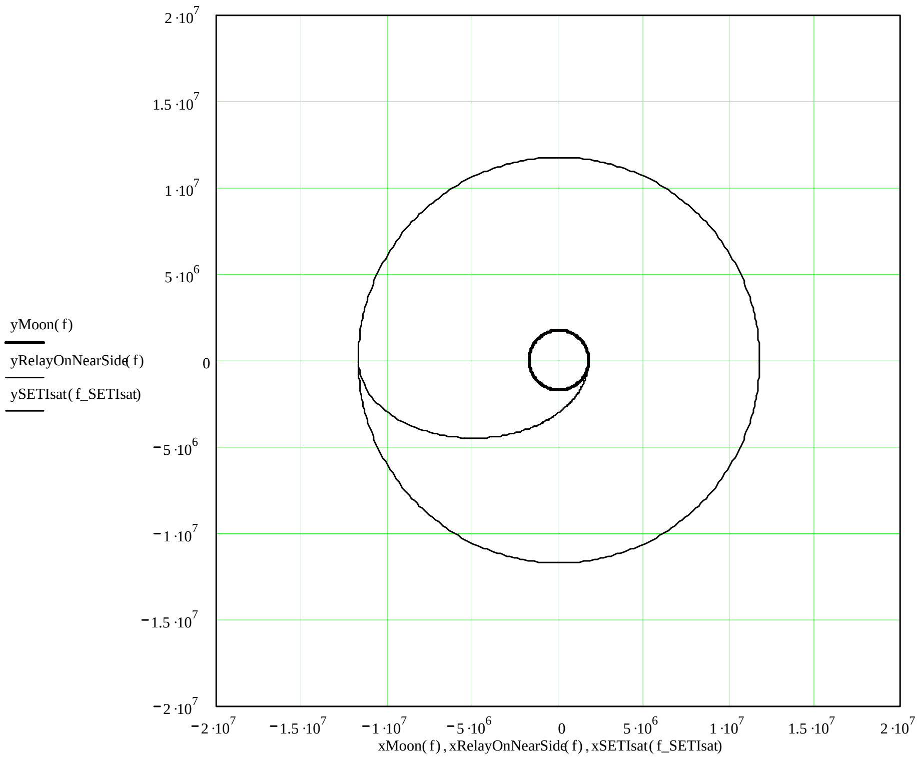

Figure 6.

The "RadioMoon" space mission in the Moon's equatorial plane: in the example, the orbiter is at 10,000 km and the Hohmann transfer lets a Phased Array be landed inside Crater Daedalus.

8. Time Spent Inside the Quiet Cone by the RadioMoon Spacecraft

We now wish to point out an equation expressing how much time would a satellite orbiting the Moon spend inside the Quiet Cone. This is an important factor in order to plan future space missions intended to put scientific satellites in orbit around the Moon. In fact, considerable benefits would be provided by Lunar small probes were they carrying small radio devices telling us how much noise reduction one has inside the Quiet Cone. In agreement with the jargon adopted in Section 7, the (generic) scientific satellite orbiting the Moon is called "RadioMoon" in Figure 7 below, but, of course, the results discussed in this section applie to any spacecraft to orbit the Moon.

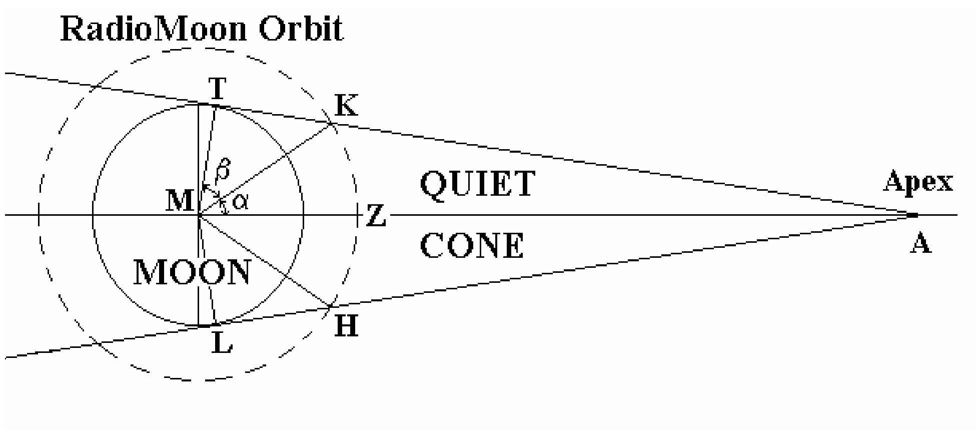

Figure 7.

Finding how much time would a satellite (called "RadioMoon" here) spend inside the Quiet Cone was it orbiting the Moon along a circular orbit of radius $R_{MoonSat}$.

The mathematical proof of the next equation was given by the author in ref. [8] and will not be repeated here. We simply confine ourselves to describing the result: the time spent by the RadioMoon spacecraft ***inside the Quiet*** Cone while in circular orbit around the Moon with radius $R_{MoonSat}$ is :

$$t_{InQuietCone}\left(R_{MoonSat}\right) = \frac{2}{\sqrt{G\,M_{Moon}}} \cdot \sqrt{R_{MoonSat}{}^{3}} \cdot \left[\operatorname{acos}\left(\frac{R_{EarthSat} - R_{Moon}}{D_{Earth-Moon}}\right) - \operatorname{acos}\left(\frac{R_{Moon}}{R_{MoonSat}}\right)\right].$$

This is a rather complicated function of the only "free-to-be-selected" variable $R_{MoonSat}$. Contrary to what intuition might suggest, this is ***not*** a monotonic function of $R_{MoonSat}$: it actually has one minimum and one maximum, as shown in Figure 4 for the very important case where the orbital radius of the Earth-orbiting satellite, $R_{EarthSat}$, is assumed to be the geostationary one. In this case, the equation above predicts a minimum staying of 39.5 minutes inside the Quiet Cone for a circular orbit of about 600 km above the Moon surface, and a maximum staying of 42 minutes for an orbit about 3500 km above the Moon surface. For circular Moon orbits higher than this one, the time spent inside the Quiet Cone decreases pretty fast up to zero (= Moon satellite passing through the Apex of the Quiet Cone). In words, this non-monotonic character of the equation above is explained by taking into account the "conflict" between the Third Kepler's law ("higher orbits, lower speed") and the narrowing of the Quiet Cone for higher and higher orbits.

It is interesting to point out, however, that this minimum and maximum disappear if the RFI-emitting satellite around the Earth has a circular orbit of radius somewhat higher than the geostationary radius. This is shown by Figure 4, where the same solid curve as in Figure 3 is plotted again with three more similar curves added. The first two of these three new curves show the case when the Earth-orbiting RFI-emitting satellite has a circular orbit with radius twice, three times, respectively. The last (dotted) curve in Figure 4 corresponds to the highest conceivable orbital radius around the Earth: the radius equal to the distance between the Earth and the Lagrangian point L1. So, no more minimum and maximum appear, and the curves approach the "intuitively expected" monotonic behaviour.

This completes our discussion about the amount of "quiet time" available to satellites orbiting the Moon along a circular orbit laying in a plane passing through the Earth-Moon axis (maximum extent of the Quiet Cone). Notice that one such orbit could be fairly close to a Moon polar orbit, since its only requirement is that the circle must intersect the Earth-Moon axis.

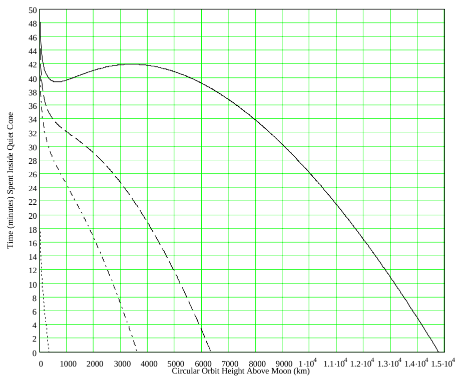

Figure 8.

The solid line shows the time (in minutes along the vertical axis) spent inside the Quiet Cone by a satellite in circular orbit around the Moon IF that there are NO radio-emitting satellites around the Earth in orbits higher than the geostationary one. The circular orbit radii above the Moon surface are measured in km on the horizontal axis. The dashed curve refers to an Earth-orbiting satellite having a circular orbit radius *twice* the geostationary orbit radius. The dash-dotted line is the case when the Earth satellite is orbiting at *three times* the geostationary orbit radius. And finally the dotted line is corresponds to a circular orbit radius equal to the *distance of the Lagrangian point L1* of the Earth-Moon system (323050 km). Notice that the last three curves show no more minimum and maximum.

Conclusions

The "Lunar Farside Radio Lab" is a Study of the International Academy of Astronautics (IAA) coordinated by this author. "As world leaders discuss a future in space that includes ambitious multinational projects such as a lunar base and the eventual colonization of Mars, the Academy has embarked upon a series of cosmic planning studies to provide decision-makers an unbiased scientific and technological basis for their commitment to these programs. These multidisciplinary cosmic studies, reviewed by one thousand academicians from 60 countries, are examining alternatives for international cooperative ventures and their probable impact on the economic and social life of the nations involved.". This is the IAA Study definition given at the IAA web site **http://www.iaanet.org/p_papers/** .

This paper is just the beginning of the true "Lunar Farside Radio Lab" Study. Much more technical material will have to be reviewed and discussed. But one goal appears to be more important that anything else: the legal protection of the Lunar Farside region in between 150° E and 150 W° at the center of which is crater Daedalus. This is the only land totally free from man-made RFI that, hopefully, will remain so for a long time to come.

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