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EARTH-MOON SYSTEM AS A COLLECTOR OF ALIEN ARTEFACTS

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Three decades of conventional SETI-experiments cover only a negligible part of the Galaxy's age, but more effective approaches could cover billions of years without any speculations about the desire and means of extraterrestrial intelligence (ETI) to communicate with us. It is shown that the Moon is a good indicator of ETI presence in the considerable part of the Galaxy during past 4 Gyr. Moreover, the Earth is a natural collector of ETI artefacts (debris, trash etc.) which could spontaneously fall on our planet.

I. INTRODUCTION

Conventional SETI-strategies, the search for signals and radiation leakage [1] reflect the habit of astronomers to study the radiations from the celestial bodies. That is why only a negligible part (~$3x10^{-8}$) of the Galaxy's lifetime is accessible to modern SETI. Hence the probability of finding an active ETI is decreased and tied in with the vulnerable speculations about necessity, direction, magic frequencies, time synchronisation, modulation etc. of electromagnetic signals. However, the search for alien artefacts, which could have accumulated on the surfaces of the Moon and the Earth during 4.5 Gyr, seems a promising alternative. Although this approach is mentioned in the literature (e.g.[2]), it is not considered in detail. Nevertheless the analysis of this problem is quite pertinent now when classical SETI is in crisis [3].

2. LUNAR ETI INDICATOR

The rare oxygen-containing atmosphere of the Earth (a good biosphere indicator) is detectable from interstellar distances [4]. About 10^4 stars capable of having inhabited planets approached the Sun to distances within 1.5 pc during the past 4.5 Gyr [5] while the Sun turned 16 times round the Galaxy centre. Moreover, ~150 stars of different types have flown through the Solar System at distances <10^4 a.u. Hence our unique planet could attract ETI attention. The Moon is a convenient site for long-term observation of the Earth. There is a variety of arguments for placing equip-ment for prolonged Earth monitoring on the Moon rather than in orbit or on the Earth itself, e.g.

1. Through screening of at least half of the meteorite flow and ionising radiation, the equipment lifetime on the lunar surface may be at least twice as long as that of a spacecraft in orbit.
2. Orbit stabilisation and orientation of an apparatus on the Moon is simple and possible without fuel for jets.
3.

Lunar soil can be used to support life of the station personnel, thermal control and repair of equipment.

4. A lunar mission may be effectively concealed from terrestrial aboriginals where as an orbital spacecraft is much easier to reveal.

5. The absence of adverse effects of atmospheric, geological and biological nature will offer longer lifetime for exploration equipment on the Moon rather than on the Earth.

6. The indisputable advantages of the Moon as an intermediate base for flights to the Earth and planets are clearly demonstrated by the rise of NASA, ESA and NASDA lunar interest.

It should be emphasised that landing on the Moon would be for ETI a necessity more than a convenience. Thus, the Moon should be an attractor of alien artefacts. Moreover, about 90 per cent of ETI 10cm-artefacts could survive under meteoroid bombardment for indefinite period [6] because of the immersion in the soil due to meteoroid impacts and dust accumula-tion.

With the Moon as an attractor and a good accumulator of ETI artefacts our satellite is an indicator of ETI presence at least for civilisations which were interested in the Earth, for the past 4 Gyr. That is why the specific principles and probable targets of lunar archaeology [7] could be useful for future missions to the Moon.

The results of lunar exploration obtained already(e.g. [8]) show that the search for alien artefacts on the Moon is a promising SETI-strategy especially in the context of the lunar colonisation plans.

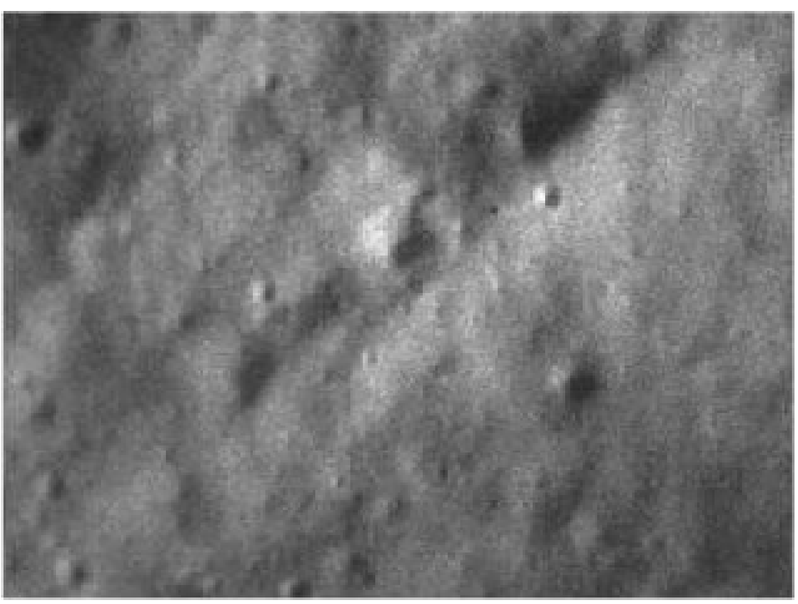

Fig. 1. The ruin-like formation near the lunar crater Lovelace photographed by the space probe Clementine on March 8, 1994 (image LHD 30055.080). This cluster of rectangular depressions occupied an area of about 13km^2.

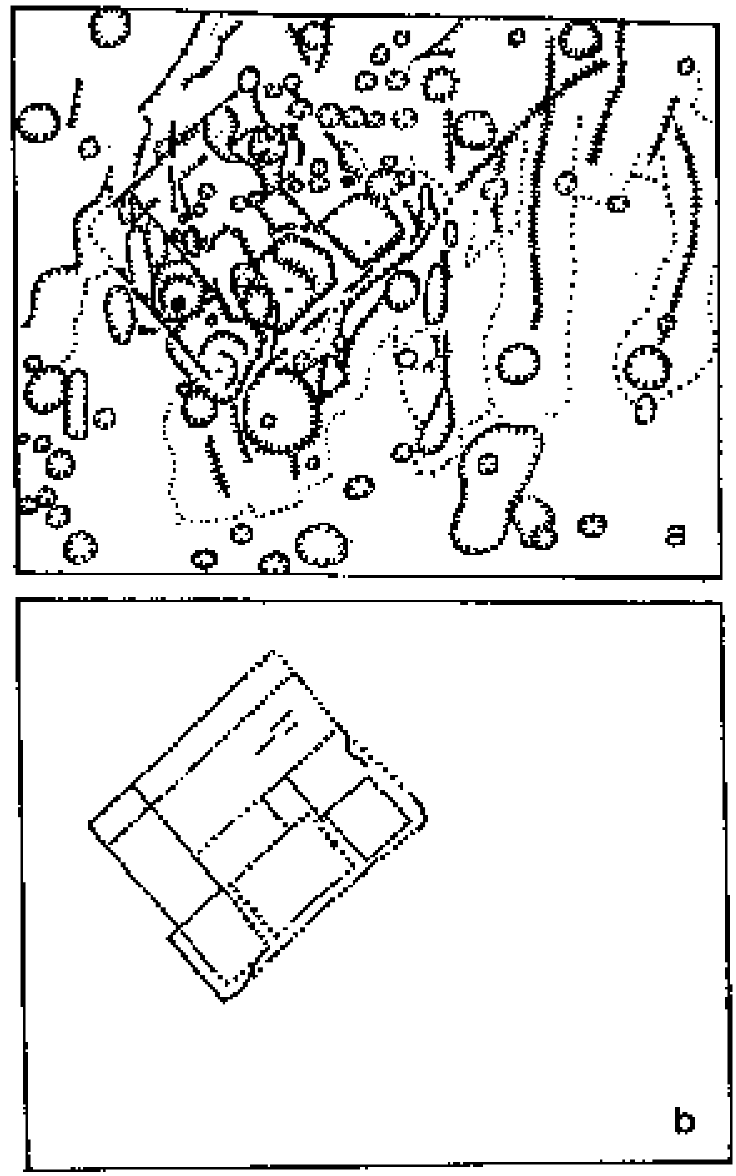

Fig. 2. Sketch map of fig. 1 (a) and the probable reconstruction of the ruin-like formation (b). The similar patterns could be preliminary targets for archaelogical reconnaissance.

For example, an unusual formation near the crater Lovelace (117º W; 82º N), which was photographed by the HIRES camera of the space probe Clementine, image LHD30055.080 (fig.1), seems to be a promising candidate for archaeological reconnaissance. This formation looks like an isolated quasi-rectangular cluster of rectangular depressions (the collapse of some subsurface caves?). The vault-like remains appear as two terraces on the depression slopes (fig.2). It suggests that there are three storeys of the hypothetical caves. The rectangularity and regularity of this ruin-like pattern is similar to modern projects for the lunar base as a subsurface construction pro-tected from meteoroids and radiation.

3. SEARCH FOR ALIEN SPACE DEBRIS

Alien space activity in the Solar System could lead to the pollution of space. At least there are interesting candidates for ETI artefacts in the orbits (e.g. [9]). Moreover, alien space debris could fall on the Earth spontaneously like our satellites do. That is why the search for candidates to such events are worth discussing.

For example, the disintegration of artificial satellites into debris of different chemical composition shows in the form of multicoloured bolides. Such phenomena were unknown in meteoric astronomy before 1957. However, I have discovered that rare multicoloured bolides have been observed before that time too, with artefact-like disintegrations noticed on:

- 1902, July 13 “several colours being marked” [10]);
- 1926, December 4 (the meteor trail was “divided into two longitudinal bands: the upper band of a very clear blue, sapphire colour, and the lower one of a scarlet colour” [11]);
- 1928, June 13 (“as it moved it emitted sparks of red, blue, white and green hues” [12]);
- 1933, December 18 (“The ball of fire resembled fireworks... Colours turned blue, red and green...” [13]);
- 1936, October 29 (“a rocket black formation throwing sparks of various colours” [14]).

Moreover, there are reports about some puzzling formations (“pseudometeorites”) which fell from bolides before 1957 [15-17]. Thus the Eaton meteorite, seen to fall on May 10, 1931, was so hot on falling that it burned the fingers of its finder. However, the composition of that finding corresponds to yellow brass, and the artificial alloy in terrestrial practice [18]. The new well-registered case of a similar fall, apparently of nonsatellite origin, is studied by the author [19]. These strange debris are collected and kept by the Kharkov Astronomical Observatory. It is not impossible that similar phenomena occurred millions of years ago, examples being the problem of “fossil artefacts” (found formerly in prehuman layers) are described in scientific literature [20].

Of course, the above-mentioned findings cannot be regarded as ETI evidence, rather they are illustrative of search possibilities. Unfortunately, meteoritics a priori ignores the “pseudometeorites” as a human trash. However, the search for isotopic anomalies in such curiosities could be a promising SETI-strategy.

4. TRASH FROM THE STARS?

Space activities lead to a lasting pollution of the Solar System [21]. Similarly the interplanetary space of other inhabited planetary systems could contain artefacts. Even without inter-stellar flights, the spontaneous leakage of artefacts into the interstellar medium is inevitable because:

a. light pressure expels micron-sized debris particles (e.g. from rocket engines) out of the planetary system;
b. a considerable portion of any large artefacts would be ejected by gravitational interaction with the planets. According to computer simulations of the asteroid and comet motion, 10-30 percent of small bodies leave the Solar System [22-24]);

c. Collisions between artefacts or their explosions (like spontaneous explosions of Earth satellites) in the outer parts of the planetary system could accelerate their debris up to hyperbolic velocities.

Hence, technical activities even within a planetary system lead to a diffusion of artefacts into the interstellar medium. If there are alien artefacts between the stars, some of them are likely to fall down to Earth at some time. So it is interesting to estimate the frequency of such events.

Let the velocity (v) of all artefacts in interstellar medium relative to the Sun be equal to:

$$v = [X_2 + Y^2 + Z^2 + (\sigma_1^2 + \sigma_2^2 + \sigma_3^2) /3]^{1/2} = 32.48 km/s$$

where: σ_1=38 km/s, σ_2=24 km/s, σ_3=18 km/s are the orthogonal dispersions in velocity of nearby stars; X=9 km/a, Y=12 km/s, Z=7 km/s are the components of the velocity vector of the Sun relatively to nearby stars [25].

The effective radius of the Earth's orbit for an interstellar artefact:

$$A=a[1+(V/v)^2]^{1/2}$$

where: $a=1.5x10^8$km is the radius of the Earth orbit; V=42.1km/ s is the escape velocity at 1 a.u. distance from the Sun. The probability of the fall on the Earth for an artefact at the distance of $r \leq a$ from the Sun is:

$$\omega =(R_e /a)^2,$$

where: $R_e \approx R[1+ u^2 /<v_a^2>]^{1/2}$ is the typical effective radius of the Earth (R=6371 km is the Earth's radius; u=11.2 km/s is the geocentric escape velocity; $<v_a^2>=v^2 +1.5V^2$ is the average square of geocentric velocity of artefacts).

The number density of artefacts is:

$$p=p_o \gamma \varepsilon MC/m,$$

where: $p_o =4.43x10^{-42} km^{-3}$ is the stellar density near the Sun [25]; γ =0.3 is the fraction of stars with planets among the nearby stars as estimated from stellar IR-excesses indicating protoplanetary disks and from statistics of angular momenta in binaries [26]; $M=2.3x10^{21}$ kg is the mass of potential raw material for the artefact manufacturing in the planetary system (the total mass of asteroids in the Solar System [25]); C is the part of raw material transformed into the interstellar artefacts; m is the typical mass of artefact; and e is the fraction of planetary systems generating interstellar artefacts among the nearby planetary systems.

Then the frequency of ETI artefact falls is:

$$f = \pi \, prvA^2 \omega \square 3.5x\ 10^{-11} \text{ [kg/s]} \, \varepsilon \, C/m.$$

For m=0.1kg the upper limit on f could be estimated, taking into account that e≤ 1 and C≤ 1. Then the average time between the falls of such ETI artefacts is 1/f≥ 91yr . Let $\varepsilon = 10_{-2}$ and $C=10^{-2}$ (the artificial ~5%-erosion of asteroids could be realised during geological lime or especially with exponential growth of space manufacture [27]). Then the Earth could accumulate about *five thousand* of 0.1kg-artefacts during $4.5x10^9$ years.

They could survive breaking in the atmosphere, at least in part Thus, according to the known Fisher's equation ($m/m_o = exp[-\sigma v^{*2}/2]$, where: m and m_o are the final and initial meteoroid's masses, respectively; σ is the ablation coefficient; v* is the initial geocentric velocity of the artefact), the survived part of the artefact is $m/m_o > 0.01$ if $v^{*2} < 9.2/\sigma$. Assuming accidental orientation of the heliocentric velocity of artefact near the Earth ($v_h = [u^2 + V^2 + v^2]^{1/2} = 54.3$ km/s), we can estimate the probability of the survival condition $v^* = |v_h - v_e| < (9.2/\sigma)^{1/2}$ (where v_e=29.9km/s is the Earth orbital velocity):

$$W=[1-(v_h^{\ 2} + v_e^{\ 2} - 9.2/\sigma)/(2 v_h v_e)]/2$$

So, artefact finding is possible (W>0) at $\sigma < 1.5x10^{-8}\ s^2/m^2$. For the common meteorites it is accepted that $\sigma \sim 2x10^{-8}\ s^2/m^2$ [28]. Nevertheless, there are materials where the heat of destruction (Q) differs considerably from that of meteorites ($Q_o = 8x10^6$ J/kg [28]). For example, the boron artefact has the heat of fusion and sublimation Q=5.53x107 J/kg [29]. Hence s=so Qo/Q=2.9x10-9 s2/m2 and W=0.40. Therefore, the finding of alien heatproof artefacts on the Earth is not excluded even without interstellar flights.

5. CONCLUSION

There are interesting nonclassical SETI possibilities which look more effective and promising than the conventional search for radio/laser signals. Unfortunately, new approaches conflict with the mental habits of astronomers, geologists and geochemists in studying natural formations and processes. This habit factor leads most specialists to an a priori rejection of search for alien artefacts on the surfaces of the Moon and the Earth. Nevertheless, invaluable information about inhabitabil-ity (or uninhabitability) of our Galaxy during its total lifetime may be found just there.

6. ACKNOWLEDGEMENT

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