CAN HUMANITY INFLUENCE THE HABITABLE ZONE

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Playing with Planets
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Abstract

In this paper we have discussed the radius of the habitable zone for exoplanets. The universal formula for the radius of the habitable zone is obtained. The radius depends only on the *fine structure constant for electromagnetic interactions* and the *ratios of the Planck mass / proton mass, and proton mass/electron mass.* For the present Epoch the width of the habitable spherical shell is of the order of 0.8 AU. In the future , in the case of Doomsday Humanity can escape the End by changing the values of Nature constants

Introduction

The habitable zone (HZ) is the circumstellar region inside which a terrestrial planet can hold permanent liquid water on its surface. A terrestrial planet that is found beyond the HZ of its star could still harbor life in its subsurface, but being unable to use starlight as a source of energy, such endolithic biosphere not be likely to modify its planetary environment in an observable way . In the solar system, in situ searches for biological activity in the surface for instance Mars or Jupites's satellite Europa could in principle be carried out. But with exoplanets presumably out of reach for in situ exploration signs of life will have to be searched via signatures of photosynthetic processes in the spectra of planets found in HZ of their stars. For exoplanets "habitable" thus implies surface habilability.

A planet found in the HZ is not necessary habitable. The maintenance of habitable conditions on a planet requires various geophysical and geochemical conditions. Only some of them, those that have a direct influence on the atmospheric properties are discussed. Many factors may prevent (surface) habitability. To give several examples the planet may lack water, the rate of large impacts may be too high, the set of ingredients necessary for the emergence of life (so far unknown) may have not been there, gravity may be to weak to retain a dense atmosphere against escape processes. The atmosphere CO_2 or the planet could have accreted a massive H_2 He envelope that would prevent water from being liquid by keeping the surface pressure to high.

However it must be recognized that being at the right distance from the star is thus only one of the necessary conditions required for a planet to be habitable. In our considerations we e assume that the planet satisfies only one condition.

The amount of superficial water must be large enough so that the surface can host liquid water for any temperature between the temperature of the triple point of water 273 K and the critical temperature of water T_C = 647 K.

1. The habitable zone in the Solar System and neighbors

In the Solar System the HZ includes: Mercury, Venus, Earth and Mars. In Table 1 we present the orbits parameter for those planets and additionally for the Ceres the "pseudoplanet" which was a result of the planetary accident in Solar System.

Table 1

Planet	Semi-major axis [AU]	Year/Earth-year
Mercure	0.4	0.24
Venus	0.7	0.8
Earth	1	1
Mars	1.5	1.8
Ceres	2.8	4.6

As can be realized for the planets in HZ, average semimayor axe is of the order ~1.3 AU. The minimal condition for the start the life in HZ is the chemistry->biochemistry transition. In the following we assume that that transition is for a granted. The representative for the chemistry are the elementary chemistry law, for example the Dalton law and Avogadro number. Astronomersaren't terribly worried about the ups and downs of the real estate market in the Sun's neighborhood. In fact, they're willing to look at all of the options, regardless of what type of star provides the light and heat. A group from Georgia State University is using the data they have collected on the nearest stars to estimate what they call the ``habitable real estate" around each of the Sun's neighbors. This habitable real estate is defined as the region around a star where a planet could sustain liquid water.

The nearby real estate market is being investigated by the ECONS group, which has been using relatively small telescopes to study rby stars at the National Science Foundation's Cerro Tololo Inter-American ervatory in the Chilean Andes since 1999.

The RECONS team is using measurements of the stars' observed brightnesses at optical and infrared wavelengths and the stars' distances found via the trigonometric parallax method. Together, these data allow them to derive the stars' intrinsic luminosities, colors, and distances, which ultimately yield accurate estimates of the stars' temperatures and sizes. The team is the first to make a concerted effort to make the measurements for all of the nearest stars, and the first to look at each different type of star in the sample --- whether the stars are bigger and hotter than the Sun like white Sirius, similar to the Sun like yellow Alpha Centauri A, or smaller and cooler than the Sun, like the orange and red stars that make up most of the nearest stars, including Alpha Centauri B and Proxima Centauri.

The group was interested in the habitable real estate around red dwarf stars, which are 50-90% smaller than the Sun and much cooler. Although they comprise more than 70% of the Galactic population, they are often overlooked as hosts of planets suitable for life because they shine so feebly. To the group's surprise, although there are only three Sun-like stars of spectral type G and 44 red dwarfs of spectral type M within 5 parsecs (16.4 light years), all the red dwarf habitable real estate added together did not equal the habitable zone of even one Sun like star. It's much like finding that a single large island has more good places to live than several dozen small islands. Another area of interest for the team was to understand the effects on habitable zones when more than one star is in a system. Roughly half of stars like the Sun have companion stars (called binary star systems), while about a third of red dwarfs have stellar companions. In many such systems, the stars are separated by enough distance to leave good real estate around each star where life could settle in comfortably. For example, the nearest star system contains three stars --- the Sun-like star Alpha Centauri A and the somewhat cooler star B in close orbit around one another, and the red dwarf Proxima Centauri that is much farther away. Stars A and B orbit in such a way that the distance separating them changes from similar to the distance between the Sun and Saturn to a bit larger than the distance between the Sun and Neptune. ``. The surprising result was that when the light and heat of the two stars was combined, the team found that the other star in the system did not significantly change the size of the habitable zone, regardless of where it was in its orbit. ``One is expected that Alpha Centauri A and B might interfere with each others' habitable zones, but the areas of the available good real estate around each star is affected by less than 1%,''. Distant Proxima is completely unaffected by the other two stars. Apparently, the real estate market in the nearest star system has not one, but three promising locations for life.

2 The model

In a "planetary model" of the hydrogen atom the electron year is of the order of 10 $^{-17}$s. It is interesting to observe that the following chemical - astronomical coincidence holds

$$AT_e \simeq T_{Earth} \qquad (1)$$

In formula (1) A is the Avogadro number, T_e is the electron year and T_{Earth} = Earth year ≈10 ^{7}s.In the following we assume that in HZ chemistry is represented by Avogadro rule. that formula holds for Earthlike planets in HZ.

For all planets we have the Kepler law

$$T_{Earthlike}^{2}=\left\{\frac{2\pi m_{Earthlike}}{\left(-m_{Earthlike}K\right)^{1/2}}\right\}^{2}R_{Earthlike}^{3}, \qquad (2)$$

where

$$K=-GMm_{Earthlike}$$

and $R_{Earthlike}$ is the semi-mayor axis for Earthlike planets, M is the star mass.

For the stars from main sequence the star mass can be calculated according to the formula Chandrasekhar – Landau formula

$$M=\alpha_{G}^{-3/2}m_{p} \qquad (3)$$

where α_G is the "fine structure constant" for the gravitation. Considering that

$$Am_{p}\sim 1\text{ g} \qquad (4)$$

the semi- major axes for Earthlike planets can be calculated from formula (2)

$$R_{Eartlike}[\mathrm{AU}]=1.29\times10^{-11}\,(1/\alpha)^{4/3}\,(M_{planck}/m_{proton})^{1/3}/(\beta)^{2/3} \qquad (5)$$

In formula (5) α is the fine structure constant=1/137 and β is the ratio $m_{proton}/m_{electron}=1836$. M_{Planck} is the Planck mass, $M_{Planck}=(\hbar c/G)^{1/2.}=10^{19}$ GeV

As was shown in paper[1] the theoretical uncertain for α is

$$1/180<\alpha<1/85 \qquad (6)$$

In Fig.1 the semi-major axis as the function of α is presented. It can be seen that only Venus (0.7 AU), Earth (1 AU) and Mars (1.5AU) fulfill the inequality (6). In the following we will consider the sphere shell with radiuses R=0.7 to R=1.5 AU as the habitable zone.

3. The habitable zone for exoplanets

The contemporary exoplanet catalogs presents data for *circa* 300 exoplanets. In Fig. 2 we present the semi- major axis of exoplanets as function of the mass of central star in Log-log scale [2] The two clusters of the planets can be seen. The first one for the R=1.3 AU and second for R= 0.04 AU . According to our definition the first group of planets can be described as the candidates for habitable exoplanets

References

[1] J D Barrow, FJ Tipler, *The anthropic cosmological principle,* OUP,Oxford, 1986

[2] The Extrasolar Planets Encyklopaedia

Figure captions

Fig.1 The habitable zone for Solar system. Violet-> Venus, Lightgreen-> Earth, Green->Mars

Fig2. The habitable exoplanets, R{AU]=1.3

Fig.1

Out[136]=

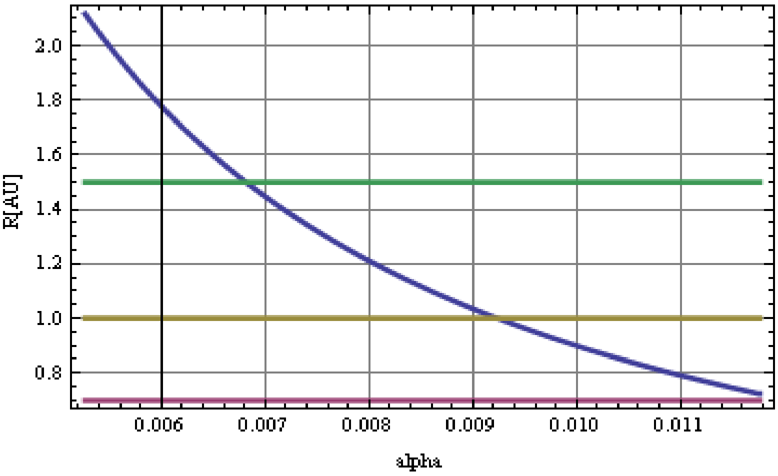
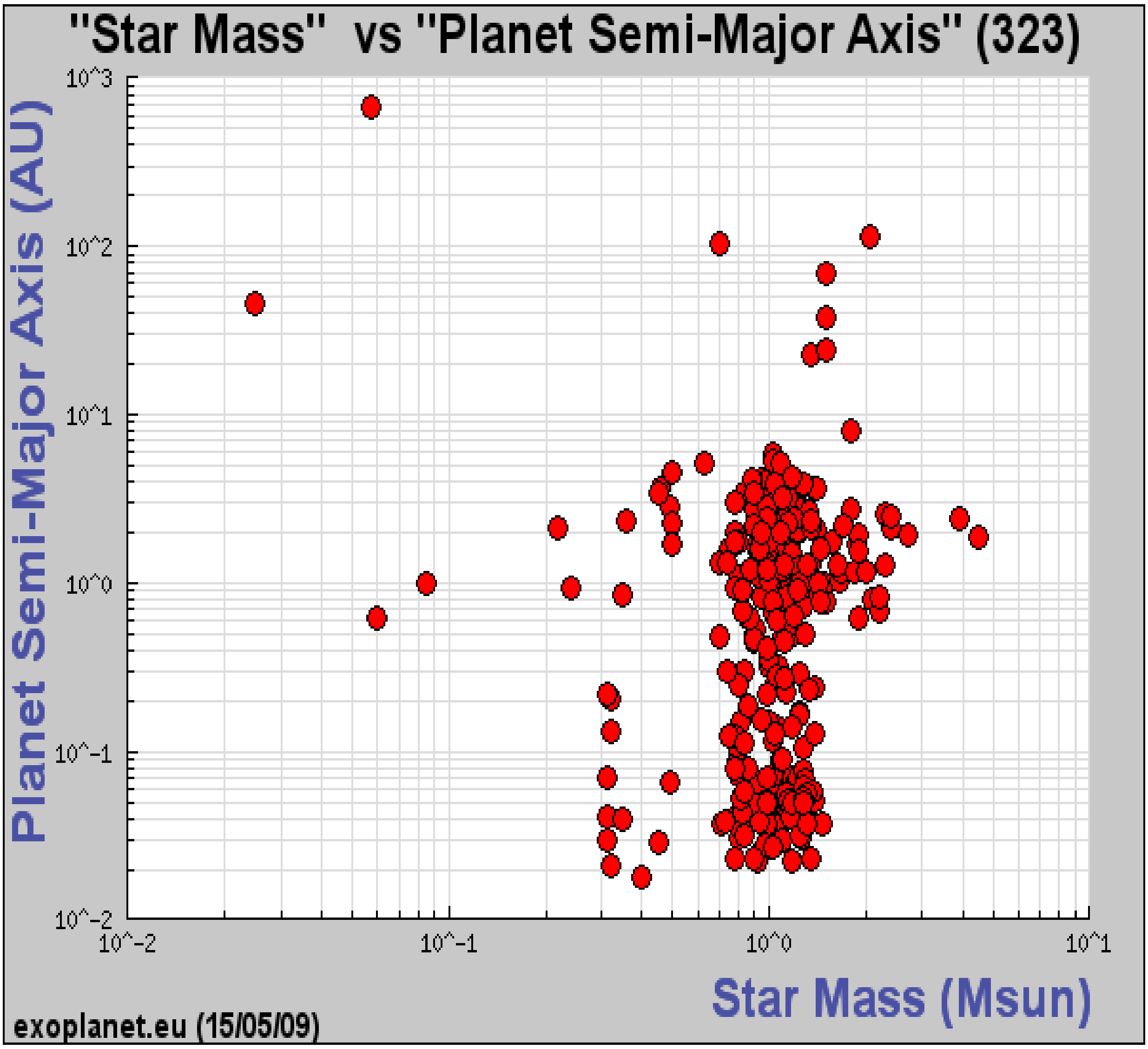


Fig.2


"Star Mass" vs "Planet Semi-Major Axis" (323)
Planet Semi-Major Axis (AU)
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-2
10^-1
10^0
10^1
Star Mass (Msun)
exoplanet.eu (15/05/09)