The Ecosphere and the Value of the Nature Constants

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Abstract

Following the coincidence A x atomic year $\sim$ Earth year (s), (A =Avogardo number, atomic year= $a_B/\alpha c$, a_B = Bohr radius, α = fine structure constant, c = light velocity) and considering the ,,niche" for α, i. e. $180^{-1} \leq \alpha \leq 85^{-1}$, the Ecosphere radius is calculated.

Key words: Fine structure constant; Planet orbit radii.

Introduction

The existence of Extra-Solar planets is well established. In the contemporary status of the searching program (e. g. DARWIN space infrared interferometer project) the following categories of extra-solar planets are described: Definite planets (20), possible planets (8), microlensed planets (5), borderline planets (2), dust clump planets (7) and pulsar planets (4), number in paranthesis denotes the number of planet.[1] It is well known that round the Sun the habitable zone – Ecosphere exists. Within the Sun Ecosphere are: Venus, Earth and Mars and Sun. It will be interesting to calculate the Ecosphere radius for "average" star with mass $M_s = a_G^{3/2} m_p$ (a_G = the gravity fine structure constant and m_p = proton mass).

To that aim in this paper we investigate the possibility of the calculations of the planet orbit radii as the function of the fine structure constant α. We argue that the Ecosphere is defined as the part of space rounded the star which can be calculated assuming the present day value of the electromagnetic fine structure constant. Considering the existence of the ,,niche" for fine structure constant we calculate the niche for planet orbit radii and obtain $R_{rel} = R(\alpha)/R(\alpha = 1/137) = 0.5 - 1.5$ where R_{rel} denotes the relative orbit radii. In the case of the Solar system in Ecosphere we find out the orbits of Venus, Earth and Mars. Considering the agreement of the calculation with the Ecosphere radius for Solar system we argue that our model for habitable zone can be applied to other planet systems also.

Coincidence

In paper [1] the quantum heat transport on the atomic, nuclear and quark scale was discussed and the characteristic time scales were obtained. For atomic scale:

$$\tau_a = \frac{\hbar}{m_e \alpha^2 c^2}, \tag{1}$$

where m_e is electron mass, α is the electromagnetic fine structure constant, c is the light velocity. For nuclear scale:

$$\tau_n = \frac{\hbar}{m_n (\alpha^s)^2 c^2}, \tag{2}$$

[1] Data taken from http://art.star.rl.ac.uk/darwin/planets

where m_n denotes nucleon mass, $\alpha^s \sim 0.15$ is the coupling constant for strong interactions. In the case of free quark gas (if it exist!):

$$\tau_q = \frac{\hbar}{m_q(\alpha_s^q)^2 c^2} \tag{3}$$

and α_s^q, m_q are the fine structure constant for quark-quark interaction and quark mass respectively.

The atomic time scale, τ_a, is proportional to the ,,atomic year", T_a, viz.:

$$\tau_a = \frac{\hbar}{m_e \alpha^2 c^2} \sim \frac{a_B}{\alpha\, c} = T_a, \tag{4}$$

where a_B is the Bohr radius.

It is quite interesting to observe that the ,,coincidence" holds:

$$\begin{aligned} A\, T_a &\sim T_{\text{Earth}}, \\ A\, m_p &= 1g, \end{aligned} \tag{5}$$

where A is the Avogardo number, $A = 6.02\, 10^{23}$, $m_p = 1.66\, 10^{-27}$ kg is the proton mass and T_{Earth} denotes the Earth year (in seconds).

From Kepler law the relation $T_{\text{Earth}} \to R_{\text{Earth}}$ can be concluded:

$$T_{\text{Earth}}^2 = \left(\frac{2 m_{\text{Earth}} \pi}{(-m_{\text{Earth}} K)^{1/2}} \right)^2 R_{\text{Earth}}^3. \tag{6}$$

In formula (6) we approximate Earth orbit as the circle with radius R_{Earth} and m_{Earth} is the Earth mass, K is equal:

$$K = -G m_{\text{Earth}} M, \tag{7}$$

where G is gravity constant and M denotes the mass of the central body (the Sun) which creates gravity forces. In the following we approximate the M mass of the central body by the mass of the ,,average" star [2, 3]

$$M \cong a_G^{-3/2} m_p = N m_p, \tag{8}$$

where $N = a_G^{-3/2}$ is the Landau-Chandrasekhar number, a_G denotes the fine structure constant for gravity force. Comparing formulae (5) and (6) one obtains:

$$R^{3/2} = \frac{A \hbar c}{2\pi\alpha^2} \frac{1}{m_e c^2} \left(\frac{M_{pl}}{m_p} \right)^{1/2} \left(\frac{\hbar c}{m_p c^2} \right)^{1/2}. \tag{9}$$

In formula (9) for planet radius we omit the subscript ,,Earth" because the radius does not depend on the planet mass. The R denotes the planet orbit radius for average star with mass described by formula (8). The planet radius depends only on the three fundamental constant of the Nature: $G, \hbar, c$. The mass $M_{pl} = (\frac{\hbar c}{G})^{1/2}$ is the Planck mass.

Considering formula (5), $A\ m_p$=1 g the planet radius (9) can be formulated in more ,,elegant" form:

$$R^{3/2} = \frac{\hbar c}{m_p \alpha^2} \frac{1}{m_e c^2} \left(\frac{M_{pl}}{m_p} \right)^{1/2} \left(\frac{\hbar c}{m_p c^2} \right)^{1/2}. \tag{10}$$

The dependence of R on α is quite interesting. For, it is well known that grand unified theories allow very sharp limits to be placed on the possible vales of the fine structure constant in a cognizable universe. The possibility of the doing physics on the background space-time at the unification energy and the existence of stars made of protons and neutrons endorse α in the niche [4]:

$$\frac{1}{180} \leq \alpha \leq \frac{1}{85} \tag{11}$$

or [5]

$$\frac{1}{195} \leq \alpha \leq \frac{1}{114}. \tag{12}$$

It is interesting to observe that one obtains the niche for planet radii — the Ecosphere which is the consequence of formulae (11) and (12). The Ecosphere spans from $R_{rel} \sim 0.5$ to $R_{rel} \sim 1.5$. In the case of the Solar system in this niche we find only the orbits of Venus Earth and on the border of the Ecosphere: Mars.

Considering the agreement of the calculations present in this paper with the habitable zone for Sun, we argue that our model for Ecosphere can be applied to other planet systems (other "worlds") also.

Results

In conclusion in the paper the Ecosphere radius as the function of α - fine structure constant was calculated. Following the existence of the niche for α the niche for planet orbit radii was obtained. In the Sun Ecosphere only the orbit of Venus, Earth and Mars are placed. We argue that the formula (10) describes the Ecosphere radius for other planet systems (other "worlds") also. Moreover with the new results concerning a time – varying fine structure constant [6] we speculate that for a distant planetary systems the Ecosphere can be quite different. The change of Ecosphere radius as the function of α can be calculated from formula (10).

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