LOCALIZATION OF BOUNDARIES OF LIFE OF THE EARTH'S TYPE IN THE STAR CLUSTERS. N. I. Perov[1] and Kondratieva A. V.[2], [1]Astronomical Observatory, State Pedagogical University, Respublikanskaya St, 108. Yaroslavl, 150000. Russia. E-mail: perov@yspu.yar.ru., [2]Astronomical Observatory, State Pedagogical University, Respublikanskaya St, 108. Yaroslavl, 150000. Russia. E-mail: AleshaKondratieva@yandex.ru

Introduction: In the last decades several systems of satellites of the giant planets have been discovered. Moreover, near of the all giant planets the system of rings has been revealed [1]. The discoveries of the new exosolar systems cause the problem for searching of planets of terrestrial type. The simple analytical models of motion of these celestial mechanical systems are not found.

In 2008 several interesting papers devoted the central configurations have been appeared [2], [3]. The authors of these papers found new central configurations without, as a rule, paying attention: a) stability of the central configurations; b) determinations of the corresponding librations points; c) applications of these dynamical models for the real celestial mechanical systems.

In work [4] 4-body central configurations are investigated. Here consider N-body central configurations, in particular a stable four body central configuration. (In according with Winter [5] I vectors $\boldsymbol{R}_J$ determined the positions of I bodies of mass $m_1,\ldots, m_I$ at the baricentric coordinates system form the central configuration in respect of positive constants of $m_1,\ldots, m_I$, if the attractions force, acts upon J-body at the fixed time moment, is in proportion to the mass m_J and vector $\boldsymbol{R}_J$.)

Estimation of area of existence of the life of terrestrial type in threefold system: Let's consider system from three heavenly bodies: two stars, those temperatures and radiuses are equal ($T_1 = T_2$; $R_1 = R_2$) and a planet with temperature T_p and radius R_p accordingly.

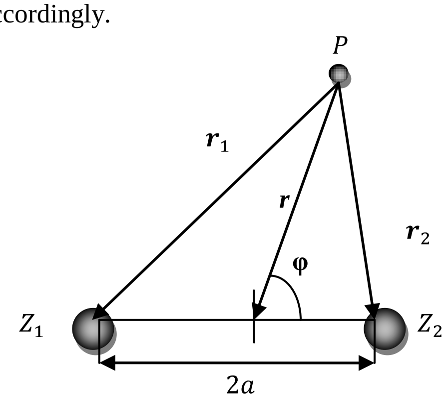

Fig.1. Threefold system: two stars of type of the Sun and planet of terrestrial type.

Based on the law of Stefan-Boltzmann we have

$$\left(\frac{4\pi R_Z^2\,\sigma T_Z^4}{r_1^2}+\frac{4\pi R_Z^2\,\sigma T_Z^4}{r_2^2}\right)\pi R_p^2 = 4\pi R_p^2\,\sigma T_p^4; \qquad (1)$$

After making replacement: $\beta = \frac{2\pi R_Z^2 T_Z^4}{a^2 T_p^4}$; $x = \frac{r^2}{a^2}$, it follows

$$\beta(1+x)-(1+x)^2+4x\cos^2\varphi = 0 \qquad (2)$$

and

$$\frac{r}{a} = \sqrt{\frac{(\beta-2+4\cos^2\varphi)+\sqrt{(\beta-2+4\cos^2\varphi)^2+4(\beta-1)}}{2}}. \qquad (3)$$

For the initial date:
$R_z = R_{sun} = 700000\ km$;
$T_z = 6000\ K; T_{p1} = 273\ K; T_{p2} = 323\ K$;
$a = 150000000\ km; \sigma = 5.67 * 10^{-8}\frac{W}{m^2K^4}$; the dependences $\frac{r}{a}$ (φ) at $T_{p1} = 273\ K$ and at $T_{p2} = 323\ K$ in polar co-ordinates are presented in Tab.1.
$\beta_{Tp1} = 31.926$; $\beta_{Tp2} = 16.293$;

Table1. Distance (from the origin of co-ordinates) of "a planet of terrestrial type" with liquid water in system of two stars similar to the Sun.

φ	0°	15°	30°
$\frac{r}{a}$(φ)atβ_{Tp1}	5,90036	5,87816	5,81720
45°	60°	75°	90°
5,73297	5,64761	5,58440	5,56111
φ	0°	15°	30°
$\frac{r}{a}$(φ)at β_{Tp2}	4,36966	4,34012	4,25866
45°	60°	75°	90°
4,14523	4,02926	3,94268	3,91062

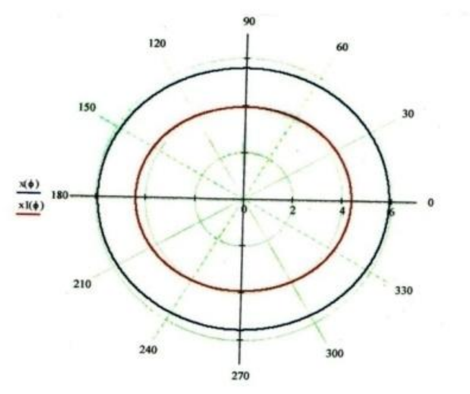

Fig. 2. The region, concluded between two ellipses is the most probable zone of position of planets suitable for a life with liquid water on the surface.

Estimation of regions of existence of a life of terrestrial type in system of four bodies: Let's consider a central configuration of three stars, located in tops of an equilateral triangle with the side of a, $m_1 > m_2 = m_3$ and planet with mass of m_0, laying on a straight line, connecting m_1 and the middle point, placed between m_1 and m_2.

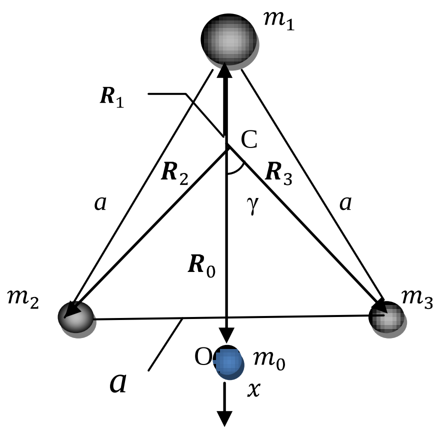

Fig. 3. Four-body system: three "stars" and a planet. C is the center of weights of system, $\boldsymbol{R}_1, \boldsymbol{R}_2, \boldsymbol{R}_3$ – are radii-vectors, *Ox* – the axis chosen for the directing.

The system in the figure 3 is in a movement condition. For the star with mass m_1 we have

$$m_1\ddot{\boldsymbol{R}}_1 = -2G\frac{m_2 m_1}{a^2}\frac{\boldsymbol{R}_1}{R_1}\cos\frac{\pi}{6}\ ; \quad (4)$$

$$\ddot{\boldsymbol{R}}_1 = -\omega_{R_1}^2\boldsymbol{R}_1\ . \quad (5)$$

Angular velocity $\omega_{R_1}^2$:

$$\omega_{R_1}^2 = \frac{Gm_2\sqrt{3}}{a^2 R_1}. \quad (6)$$

For the centre of mass of the system:

$$m_1\boldsymbol{R}_1 + m_2\boldsymbol{R}_2 + m_3\boldsymbol{R}_3 = 0.$$

So,

$$\omega_{R_2}^2 = \frac{G}{a^3}(m_1 + 2m_2). \quad (7)$$

$$\omega_{R_1}^2 = \omega_{R_2}^2$$

$$R_1 = \frac{am_2\sqrt{3}}{m_1 + 2m_2}\ ; \quad (8)$$

$$R_2 = a\frac{\sqrt{m_1^2 + m_1 m_2 + m_2^2}}{m_1 + 2m_2}; \quad (9)$$

$$^{m_1}/_{m_2} + 2 =$$

$$= \frac{^{m_1}/_{m_2}}{\left(\frac{R_1}{a}+\frac{R_0}{a}\right)^2\frac{R_0}{a}} + \frac{2\left(\frac{R_1}{a}+\frac{R_0}{a}-\frac{\sqrt{3}}{2}\right)}{\left(\frac{R_2^2}{a^2}+\frac{R_0^2}{a^2}-2\frac{R_2}{a}\frac{R_0}{a}\cos\gamma\right)^{3/2}\frac{R_0}{a}}; \quad (10)$$

Now we shall consider tree cases.

1. $\boldsymbol{m_2 = m_3 = m_{sun}; m_1 = 368 m_{sun}}$.

Using equation (1) and value of the albedo of the planet equals 0.3 we find

for $T_{p1} = 223\ K$, a_1=35.39327 AU;

for $T_{p2} = 323\ K$, a_2=16.87100 AU.

2. $\boldsymbol{m_2 = m_3 = m_{sun}; m_1 = 10^6\, m_{sun}}$;

To similar case 1, we find distance a for $T_{p1} = 223\ K$ and $T_{p2} = 323\ K$.

At such relation of mass of bodies we have the following:

a_1=13000.17067 AU; a_2=6196.81467 AU.

3. $\boldsymbol{m_2 = m_3 = m_{sun}; m_1 = 2 * 10^{11} m_{sun}}$;

In this case the corresponding distances are equal to a_1= 579328.6667AU; a_2= 276149.3333AU.

Conclusion: If the relation of mass of stars is increasing, then parameter a (the distance between bodies) also increases. Accordingly, the region of existence of the life of terrestrial type more and more keep away from the centre of mass of threefold system of stars that considerably complicates search of planets similar to the Earth. In work [4] of Perov N.I. and Medvedev J.D the attention is paid, that system, similar considered above the central configuration of four bodies (Fig. 3) is stable due criterion of Luapunov at the relation of mass of components $m_1/m_2=m_1/m_3>367.0540108$. So, it follows that searching for planets with stable orbits in multiple star systems should be made at appreciable distinction of mass of components.

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