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The evolution of the Solar activity and planet formation

T. Abdulmyanov

Kazan State Power Engineering University, Kazan, Russia (abdulmyanov.taguir@yandex.ru / Fax: +7-843-562-43-36)

Abstract

The simulation of the formation of planetary systems is considered together with the processes of star formation. It is discussed the motion of the shock wave in the direction from the star center to the periphery.

1. Introduction

The dynamic of the compression of proto-stellar cloud was first investigated in 1964 by Japanese astrophysicists Hayashi et all [4].The theory of Hayashi allows to find an adequate explanation of many observations, including to changes of the brightness of the star FU Orionis. G. Herberg found that the brightness of the star for 120 days increased by 250 times. Such changes in the brightness of the star FU Orionis were interpreted as a transition of the proto-star from stage of rapid compression into the stage slow compression. The shock wave at this time goes beyond the surface of the proto-star and the brightness of the star rapidly increases.

2. The model of the radial wave

In order to clarify the connection between the formation mechanism of the star and the mechanism of association of gas and dust particles, we consider the motion of the shock wave in the direction from the star center to the periphery. The boundary value problem for the wave equation is as follows: $u_{tt} = \alpha^2 \Delta u$, where $u(r, \varphi, t)$ – wave height, α - constant characterizing the source of the waves, Δ - the Laplace operator. The initial and boundary conditions are defined as follow:

$$u(r, \varphi, 0) = f(r) = \sum_{n=0}^{20} n J_0(\lambda_n r / R_0), \, u_t(r, \varphi, 0) = 0, |$$

$$u(0, \varphi, t) \mid < \infty, u(R_0, \varphi, t) = 0, \qquad (1)$$

where J_0 - Bessel function of order zero, R_0 - an arbitrary constant, λ_n - the zeros of the Bessel

function of zero order. The solution of the problem (1) is considered in [3] and has the following form:

$$u(r, \varphi, t) = \sum_{\nu=0}^{\infty} \sum_{n=0}^{\infty} a_{n\nu} \cos(\alpha \lambda_{n\nu} t / R_0) \cos(\nu\varphi + \varphi_0) J_\nu(\lambda_{n\nu} r / R_0),$$

where J_ν - Bessel functions of order ν, $a_{n\nu}$ - coefficients of the Fourier series for $f(r, \varphi)$ in Bessel functions J_ν, $\lambda_{n\nu}$ - the zeros of the Bessel functions of order ν. In Fig. 1 shows the form of the wave, which corresponding to the solution $u(r, \varphi, t)$.
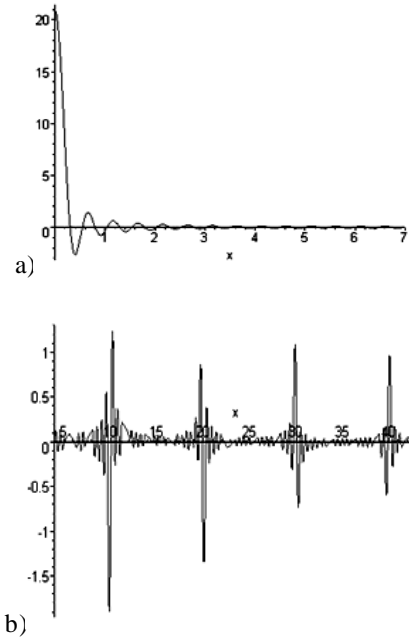

Figure 1: The singularities of the function $f(x)$: a) $R_0 = 5$; $0 \le x \le 7$ (a.e.); b) $R_0 = 5$; $5 \le x \le 40$(a.e.).

According to Fig. 1b if the value of the parameter be equal $R_0 = 5$ $a. e.$, the distance between the tops of the waves will be about 10 $a. e.$ In the case of radial waves ($\nu = 0$) wave are stationary, and in the case of non-radial waves ($\nu \neq 0$) the waves will be make a libration with respect to their position in the case $\nu = 0$. As a result of such motions of the waves will be

separate from proto-planetary disk the ring-shaped fragments (the proto-planetary ring) yet at the early stages of evolution of the proto-planetary disk. The distance between the tops of the waves will be defined by relation $d = 2R_0$. With this function $d(R_0)$ and the known distance between the orbits of the planets we will try to restore the behavior of the proto-Sun and the solar activity since the beginning of star formation. In Fig. 2 shows the form of the function $d(i) = |r_i - r_{i+1}|$, where r_i - heliocentric distance of two neighboring orbits of the planets, which are arranged in reverse order from Pluto to Mercury, and the asteroid Ceres. The stars, by the theory Hayashi, have the two-stage changes in the activity. First phase is a short phase of rapid changes in activity of the star. Second stage is the stage of slow long-periodic changes in activity of the star. In according to this theory Hayashy, we divide the values of the distances $d(i)$ between orbits of planet on the three groups: 1) 9,5 $a.\,e.$; 10,8 $a.\,e.$; 9,7 $a.\,e.$; 2) 4,3 $a.\,e$; 3,2 $a.\,e.$; 1,2 $a.\,e.$; 3) 0,52 $a.\,e.$; 0,28 $a.\,e.$; 0,33 $a.\,e.$; 0.38 $a.\,e.$ Comparing the data of distances between the orbits of the planets, we note that the variation of distances and the dependence of $d = 2R_0$ are close to each other.
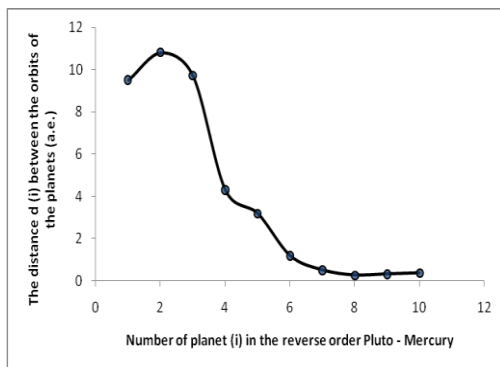

Figure 2: Changing the distance between the orbits of the planets.

Therefore we assume that the modern distance between the orbits of the planets is the result of action of the shock waves and the solar activity at the stage of star formation. Then we obtain the following procedure for the formation of planets in the solar system, which will correspond to changes of the activity of the proto-Sun and the Sun. Proto-planetary ring of Pluto, Uranus and Neptune were formed at the first stage - at the stage of short and rapid changes of solar activity. Proto-planetary ring of Mars, Earth, Venus and Mercury were formed during the slow and long-term changes of solar activity. Proto-planetary ring of other planets, also asteroid belt, were formed at an intermediate stage of rapid deceleration of solar activity. It follows, that the well-known rule of Titius - Bode, according to the wave model (1) expresses the global variations of the solar activity at the stage of star formation. Thus, according to the considered in this paper the wave model (1), the protoplanetary ring, in which later will formed planets could form in the early stages of the evolution of the protoplanetary disk. The mechanism of accretion of gas and dust particles into protoplanetary rings is seen in [1 - 2].

3. Summary and Conclusions

According to the theory of Hayashi [4] the initial radius of the proto-planetary disk was 5 $a.\,e.$ The distance between the modern orbits of Saturn and Uranus, Uranus and Neptune, Neptune and Pluto is about 10 $a.\,e.$ With the help wave model (1), these data can be interpreted as follows: 1) the proto-planetary ring of Uranus, Neptune and Pluto were formed at the initial stage of fast and short changes of the Solar activity. The proto-planetary ring of Mars, Earth, Venus and Mercury were formed during a slowly and long changes of the Solar activity. 2) The proto - planetary ring of other planets, including the asteroid belt, could be formed at an intermediate stage of rapid deceleration of the proto-Solar and the Solar activity. 3) The mechanism of accretion of gas and dust particles [2], which could operated in the proto-planetary ring, could be the cause of the accelerated formation of planets within the proto-planetary rings. As a result, within each of the proto-planetary rings could be formed only one dominant planetisimal, namely the planetisimal of planet.

References

[1] Abdulmyanov, T.: Model GW accretion, Bulletin KGEU, Kazan, Vol. 9, N 2, pp. 64-73, 2011.

[2] Abdulmyanov, T.: The problem of the gravitational accretion of particles, 43rd Lunar and Planetary Science Conference, 19 – 23 March 2012, Woodland, Texas, 2012.

[3] Abdulmyanov T.R. Defining characteristics of wave and thermal effects on structural changes in the environment, Bulletin KGEU, Kazan, Vol.12, (in print), 2012.

[4] Hayashi C., Nakazawa K., Nakagawa Y. Formation of the Solar system. Proto-stars and planets. II. Tuscon, 1985.