The Rate That the Earth Is Getting Further Away From the Sun

Fu Yuhua
(CNOOC Research Institute, E-mail:fuyh1945@sina.com)

Abstract: The mass of the Sun is reduced due to the radiation of the Sun, which causes that the planets are getting further away from the Sun. According to theoretical derivation, the rate that the planet is getting further away from the Sun equals the rate of solar mass reduction. Currently the rate that the Earth is getting further away from the Sun equals 1.02m per century, for Mercury it equals to 0.40m per century, and for Pluto it equals 40.32m per century.

Key words: Sun, planet, Earth, rate, get further away from

Introduction

Whether on not the average distance between the planet and the Sun is unchanged? The answer is the negative. The reason for this is that the mass of the Sun is reduced, so the gravitation between the Sun and planet is also reduced, which leads to the planet is getting further away from the Sun. Based on theoretical derivation, this paper discusses the rate that the planet is getting further away from the Sun.

1 The rate that the planet is getting further away from the Sun

Firstly we derive the relationship between the rate that the planet is getting further away from the Sun and the rate that the mass of the Sun is reduced.

The law of gravity reads

$$F = -\frac{GMm}{r^2} \qquad (1)$$

where, G is gravitational constant, M is the mass of the Sun, m is the mass of the planet, r is the distance between the Sun and the planet.

As the planet is getting further away from the Sun, the work of gravity is as follows

$$F_{av}(-\Delta r) = \frac{1}{2}\left(\frac{GM_1 m_1}{r_1^2} + \frac{GM_2 m_2}{r_2^2}\right)\Delta r \qquad (2)$$

where, F_{av} is the average value of gravity, $\Delta r = r_2 - r_1$.

Supposing that the mass of the planet is unchanged, namely

$$m_1 = m_2 = m \qquad (3)$$

Omitting the second order term, Eq.（2） is simplified as follows

$$F_{av}(-\Delta r) \approx \frac{GM_1 m}{r_1^2}\Delta r \qquad (4)$$

As the planet is getting further away from the Sun, its total energy is changed as follows

$$E_2 - E_1 = \frac{mv_2^2}{2} - \frac{GM_2 m}{r_2} - \frac{mv_1^2}{2} + \frac{GM_1 m}{r_1} \qquad (5)$$

In reference [1], the following formula is applied

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \tag{6}$$

It gives

$$v^2 r = GM \tag{7}$$

Substituting Eq.（7） into Eq.（5）, it gives

$$E_2 - E_1 = \frac{GM_2 m}{2r_2} - \frac{GM_2 m}{r_2} - \frac{GM_1 m}{2r_1} + \frac{GM_1 m}{r_1} \tag{8}$$

Hence

$$E_2 - E_1 = -\frac{GM_2 m}{2r_2} + \frac{GM_1 m}{2r_1} \tag{9}$$

Substituting $M_2 = M_1 + \Delta M$， $r_2 = r_1 + \Delta r$ into Eq.（9）, it gives

$$E_2 - E_1 = -\frac{G(M_1 + \Delta M)m}{2(r_1 + \Delta r)} + \frac{GM_1 m}{2r_1} \tag{10}$$

Because

$$\frac{1}{r_1 + \Delta r} \approx \frac{1}{r_1} - \frac{\Delta r}{r_1^2}$$

Therefore Eq.（10） becomes

$$E_2 - E_1 \approx -\frac{G(M_1 + \Delta M)m}{2}\left(\frac{1}{r_1} - \frac{\Delta r}{r_1^2}\right) + \frac{GM_1 m}{2r_1} \tag{11}$$

Omitting the second order term, Eq.（11） is simplified as follows

$$E_2 - E_1 \approx -\frac{G\Delta M m}{2r_1} + \frac{GM_1 m \Delta r}{2r_1^2} \tag{12}$$

According to the law of conservation of energy, we have

$$F_{av}(-\Delta r) = E_2 - E_1 \tag{13}$$

Substituting Eq.（4） and Eq.（12） into Eq.（13）, it gives

$$\frac{GM_1 m}{r_1^2}\Delta r \approx -\frac{G\Delta M m}{2r_1} + \frac{GM_1 m \Delta r}{2r_1^2} \tag{14}$$

Hence

$$\frac{\Delta r}{r_1} \approx -\frac{\Delta M}{M_1} \tag{15}$$

Namely, the rate that the planet is getting further away from the Sun equals the rate of solar mass reduction.

2 Calculation examples

Einstein's mass-energy formula is as follows

$$E = mc^2 \tag{16}$$

The given data are as follows, currentlly the total solar radiation power equals 3.86×10^{26}J/s，the mass of the Sun equals 1.98892×10^{30}kg，then we have the rate of solar mass reduction per second is as follows

$$\Delta M = -4.29\times10^{9}\,\mathrm{kg} \tag{17}$$

According to Eq.(15), the distance that the planet is getting further away from the Sun is as follows

$$\Delta r \approx -\frac{\Delta M}{M_1} r_1 \tag{18}$$

That means that, currently the distance that the Earth is getting further away from the Sun is as follows

$$\Delta r \approx 3.23\times10^{-10}\,\mathrm{m}$$

Namely, currently the rate that the Earth is getting further away from the Sun equals 1.02m per century.

Currently the distances that the nine planets are getting further away from the Sun can be found in Table 1.

Table 1 The current distances that the nine planets are getting further away from the Sun per century（unit：m）

Planet	Average distance to the Sun (Earth=1)	Distance that the planet is getting further away from the Sun per century
Mercury	0.39	0.40
Venus	0.72	0.73
Earth	1	1.02
Mars	1.52	1.55
Jupiter	5.20	5.30
Saturn	9.54	9.73
Uranus	19.18	19.56
Neptune	30.06	30.66
Pluto	39.53	40.32

3 Conclusions

Due to the mass of the Sun is reduced, the planets are getting further away from the Sun. According to theoretical derivation, from Mercury to Pluto, the current distances that the nine planets are getting further away from the Sun per century are as follows respectively: 0.40, 0.73, 1.02, 1.55, 5.30, 9.73, 19.56, 30.66, 40.32 (unit: m)..

Reference

1 Fu Yuhua, New Three laws of Planetary Motion, viXra:1504.0233 submitted on 2015-04-29.