Pioneer-effect in motion of Neptune satellites.

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Though after about twenty years studying of Pioneer-effect [1-3] the theory that the origin of this anomaly is a recoil force associated with an anisotropic emission of thermal radiation off the spacecrafts [4-6] received significant support the another approach to explanation of additional acceleration is also proposed [7]. Deviations of geodesics in 5D hyperspherical space-time with space-like fifth dimension yields [8] additional acceleration towards to Sun

$$a = -Q\dot{r}_p^2, \tag{1}$$

where Q is constant in a first approximation and r_p is distance to Sun. Sample of r_p taken from interval 6-20 AU gives $Q = (4{,}13 \pm 1{,}97) * 10^{-20}$ cm^{-1}. This model conforms to the basic properties of the Pioneer-effect, namely,

a) constant additional acceleration of apparatus on distance from 20 to 50 a.e.,

b) its increase from 5 to 20 a.e.,

c) observed absence of one in motion of planets.

Calculations of action of additional acceleration $a_p = (8{,}74 \pm 1{,}33) \times 10^{-8}$ cm/s^{-2} on radial perturbations over one century for Neptunian satellites orbits [9] gives values ΔR about 110 km for Proteus, 500 km for Triton and 30000 km for Nereid. Observed radial distance uncertainties oscillate between 2.5 km and 4.5 km for Proteus, 0.8 km and 1.2 km for Triton.

Let us evaluate action of acceleration (1) on radial perturbations of Proteus and Triton orbits. Nereid moves around Neptune too slowly and effect will be small. We define the average value of the velocity of the satellites of Neptune in a direction toward the Sun. Orbital velocity v_{orb} is 7.78 km/s for Proteus and 4.45 km/s for Triton. The value of the projection of the velocity on the axis in plane of the orbit of the satellite is

$$v_n = v_{orb} \cos\varphi. \tag{2}$$

To obtain the velocity in the direction to the Sun v_s need to multiply v_n on the cosine of the angle of inclination of the satellite orbit to ecliptic α , which is 0 degrees for Proteus and 130 degrees for Triton. The average value of the velocity square will be

$$\widehat{v}_s^2 = \frac{2}{\pi}\int_0^{\pi/2} v_{orb}^2 \cos^2\varphi \cos^2\alpha d\varphi = \frac{1}{2} v_{orb}^2 \cos^2\alpha. \tag{3}$$

As a result, we obtain the value $\widehat{v}_s$ for Proteus 5.50 km/s, for Triton 1.43 km/s . The radial velocity of the Pioneers $\dot{r}_p$ in the area, where they have acceleration a_p, is about

15 km/s. According to (1) relation of a_p to additional acceleration of the satellites in the direction of the Sun

$$N = \frac{a_p}{Qv_s^2} \tag{4}$$

is 110 for Triton and 7.5 for Proteus.

As it follows from [9], the calculated radial perturbations of Neptune satellites were obtained on the assumption of a linear dependence on the a_p. Therefore, in a first approximation, they should be proportional to the mean value of the additional acceleration. To obtain approximate values, we divide the calculated fluctuations ΔR by N and obtain 4.5 km for Triton and 14.8 km for Proteus for the considered period of time. The result can be affected by the fact that the calculation was carried out in an article for a permanent a_p, but additional acceleration of satellites $\dot{v}_s$ is changed periodically.

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