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Venus Cannot Have a Satellite Prograde or Retrograde

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Abstract

On the basis of works of King and Innanen, the limiting direct and retrograde orbits around the planet Venus have been calculated. Synthesizing this concept with the concepts of Roche limit, synchronous orbit around the planet and the tidal drags acting within it, it is shown that Venus has not retained any satellite prograde or retrograde.

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Introduction

In the Solar System, Earth has a satellite, our Moon. Earth has her companions Trojan Asteroids associated with her orbit. Mars also has two satellites Phobos and Diemos. Jupiter, Saturn, Uranus, Neptune, Pluto have extensive satellite Systems. They also have Trojan Asteroids associated with their orbits. One may have question what about Venus. Does Venus have satellite system or at least one or two satellites going around it? Why does Venus have no moon, when it is as large and as massive as Earth? One expects it to have at least one or two satellites either moving in prograde orbit or retrograde orbit. Is it that Venus never had any satellite? Perhaps it had one or two satellites but somehow they were destroyed or perhaps it has yet one or two small satellites going around it, may be in prograde orbit comparatively at small distances or retrograde orbit at a large distances which we have so far not been able to discover them, or not seriously tried to discover them. Due to vicinity of the Sun, Venus's satellite system has not developed because of two reasons, one is strong gravity of the Sun affecting the growth of satellite system and second due to heat of the Sun, material had evaporated very soon, before it could get together to form a satellite system, however, it might be that one or

two satellites might have formed before material around Venus would have evaporated, and might have, so far, survived. The question now is: From some theory, can we get some clue as to whether Venus has one or two prograde or retrograde moving satellites. To know this, works of King and Innanen come to our rescue. From the work of King and Innanen, we can calculate the limiting direct and retrograde orbits around Venus synthesizing this concept with the concepts of Roche limit, synchronous orbit around the planet and tidal drags acting within them, it is shown that Venus may not have retained any satellite direct or retrograde going around it. The reason behind this is Venus' long rotation period of 243 days. Because of this, the stationary orbit lies far off from the centre of Venus, making all orbits prograde or retrograde around Venus lie within the stationary orbit.

King formulae for limiting tidal radius r_{lim}, is given by

$$r_{lim} = \left[\frac{Gm}{\Omega^2 - d^2V/dR^2} \right]^{1/3} \quad (1)$$

Where rlim is the limiting radial distance of a grand secondary, from the secondary, m, the mass of the secondary, Ω, angular velocity of the secondary around the primary; V, the gravitational potential energy of the primary; and R, the radial distance of the secondary from the centre of the primary. If we represent the force field of the primary by an inverse square law due to its mass, M then

$$\frac{d^2V}{dR^2} = -\frac{2GM}{R^3} \quad (2)$$

Hence

$$r_{lim} = \left[\frac{m}{3M} \right]^{1/3} \times R \quad (3)$$

For the elliptical orbit

$$\Omega^2 = GM_a(1 - e^2)/R^4 \quad (4)$$

Where, a is the semi-major axis of the ellipse and e, is its eccentricity. At the perihelion point, R takes the value

$$R_p = a\,(1 - e) \quad (5)$$

And the Eqn. (1) in this case becomes

$$r_{lim} = \left[\frac{m}{(3+e)M} \right]^{1/3} \times R_p \quad (6)$$

A moon revolving around a planet that, in turn, is revolving in the same sense around the Sun will, at some limiting distance from the planet, becomes unstable because of the motion of the Sun's tidal force. If the same moon at the same distance, were to revolve in the opposite sense to the sense of the planet's revolution, it could resist the Sun's tidal force better. At greater limiting distance from the planet, this retrograde moon would eventually succumb to the Sun's tidal force. This limiting retrograde radius defines the true gravitational sphere of influence of a planet. Innanan 1979) consider the same system and uses the equation of acceleration in a rotating coordinate frame with an additional Coriolis term of magnitude $2\Omega\vartheta r$, where ϑr, is the

velocity of the star relative to the star cluster. The familiar right-hand rule immediately shows that the Coriolis term is always directed radially between the star and the star cluster. It counteracts the cluster'sgravity for direct motion of the star, but effectively supplements the cluster's gravity for retrograde motion. For the limiting direct and retrograde radii of a star around a star cluster rd and rr respectably, he gets

$$r_r/r_d = 3^{2/3} \tag{7}$$

Where

$$r_d = \left[\frac{m}{3^2 M}\right]^{1/3} \times R \tag{8}$$

For elliptical orbit one has

$$r_r/r_d = \left[\left\{5 + e + 2(4 + e)^{1/2}\right\}/(3 + e)\right]^{2/3} \tag{9}$$

For convenience, one writes

$$\left[\left\{5 + e + 2(4 + e)^{1/2}\right\}/(3 + e)\right] = f(e) \tag{10}$$

$$r_d = \left[\frac{1}{\{f(e)\}^2}\frac{m}{M}\right]^{1/3} \times R_p \tag{11}$$

It is well known fact that when a secondary, going around a primary, enters the stationary orbit around the primary, the disruptive forces start acting on it. As a result, the secondary starts spiraling in, eventually entering the Roche limit around the primary getting itself fragmented due to tidal forces of the primary. That is, the ultimate fate of a secondary revolving around its primary within the stationary orbit is to destroy itself . It is, therefore clear that if the limiting retrograde orbit around a primary lies within the stationary orbit around it, then such a primary cannot retain its secondary for a sufficiently longer period. Here, it is calculated the stationary orbit around Venus to be 1537000 km. In the case of Venus, the limiting retrograde orbit is at a distance 1452000 km which lies within its stationary orbit and this is probably the reason, why it does not have even a single satellite. The main reason behind this situation is the slow rotation of Venus. Jupiter and Saturn have rotation period ~ 10 h , so their satellites can survive in the vicinity also.

In calculating the stationary, direct and retrograde orbits around Venus, we have taken its mass = 0.815 $M_{\oplus}$, its rotational period 243 d, its mean orbital radius 0.723 AU and its eccentricity 0.007 [1-4].

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