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A2_7 Rise (and Fall) of the Planet of the Apes

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Abstract

We determine the basic physical properties of a new astronomical body created by collecting the entire primate population of the Earth in orbit. We calculate the orbital distance at which the new satellite would exert a tidal force equal in magnitude to that of the Moon on the Earth. At 4.7×10^3 m this is three orders of magnitude smaller than the 2.7×10^7 m Roche limit and well within the body of the Earth, suggesting that there is no way such a primate satellite could significantly perturb the Earth.

Introduction

At an estimate, the primate population of the Earth is 7.7014×10^9 individuals [1]. In this paper we consider the properties of an astronomical body created from this primate population and use its estimated Roche limit and the tidal force it exerts on the Earth to determine whether it could have any appreciable effect on the Earth's tides or orbit. The Roche limit is the closest distance at which a satellite can orbit its parent body without being torn apart by tidal forces.

Theory and Results

As approximately 7.7×10^9 of the 7.7014×10^9 primates on Earth are humans, the mean mass of a primate can be approximated as 62 kg, the mean mass of a human [2]. The total primate biomass is then 4.8×10^{11} kg. The mean density of a young human at a healthy weight is 1.07×10^3 kg m^{-3} [3], so from $m = \rho V$ where m is mass, ρ is density and V is volume we obtain a volume of 4.5×10^8 m^3. This value does not consider any air gaps between the bodies of the irregularly shaped primates or any gravitational contraction. As the total mass of the primates is large we make the assumption that they are pressed together by gravity and that throughout most of the structure air gaps are negligible. However, we will also assume that gravitational contraction of the primate material itself is negligible because mammals are largely composed of water.

Assuming a spherical body we apply the formula $r = (\frac{3V}{4\pi})^{1/3}$ where r is the radius of the body and V is its volume. This gives an estimated mean radius of 480 m.

As our satellite is made of over 7×10^9 individual incompressible elements we expect it to be only loosely bound together by self-gravity. It is thus comparable to a rubble-pile asteroid for which the fluid Roche limit approximation for bodies that are easily deformed by tidal forces is appropriate. The Roche limit of the primate satellite is thus given by:

$$d \approx 2.44 R_E \left(\frac{\rho_M}{\rho_m} \right)^{1/3} \quad (1)$$

Where R is the mean radius of the Earth, and ρ_M and ρ_m are the densities of the primary body and satellite respectively. Substitution of the density of the primate satellite and the radius and density of the Earth (6371×10^3 m and 5.514×10^3 kg m^{-3} [4], respectively) into equation (1) gives the Roche limit for our satellite as 2.7×10^7 m, putting the closest possible position of the (intact) primate satellite in the outer Van Allen radiation belt. This value will be used to test the plausibility of the primate satellite orbiting the Earth at a close enough distance to exert a tidal force on the planet equal in magnitude to that exerted by the Moon.

The tidal force at a point on an object is calculated by subtracting the gravitational force at the centre of the object from the local gravitational force. The formula for the magnitude of this force is [5]:

$$F_T = \frac{2GMmR_s}{{r_o}^3} \quad (2)$$

Where F_T is the tidal force, G is the gravitational constant, M is the mass of the primary body, m is the mass of the satellite, R_s is the radius of the satellite and r_o is the orbital distance of the satellite. Substituting in $m = 7.35 \times 10^{22}$ kg for the mass of the Moon, $r_o = 3.84 \times 10^8$ m for its mean orbital radius, $R_s = 1.74 \times 10^6$ m for its radius, and $M = 5.97 \times 10^{24}$ kg for the mass of the Earth gives the tidal force exerted on the Earth by the Moon as $\approx 1.8 \times 10^{18}$ N [4]. By rearranging equation (2) for orbital radius we obtain a required orbital radius of 4.7×10^3 m for the primate satellite to exert a tidal force on the Earth equal in magnitude to that exerted by the Moon.

Discussion and Conclusion

The total population of primates is unknown, but as humans are by far the dominant species assuming a number of individuals, average mass, and body density corresponding to the mean human values is not expected to have significantly altered the results. The primate satellite is assumed to be spherical, although given the assumed incompressibility of the primate material a more accurate model would have been of an irregular rubble pile.

The radius at which the primate satellite will exert a tidal force on the Earth equal to that of the Moon is 4.7×10^3 m, an 'orbit' deep within the Earth and far below the 2.7×10^7m Roche limit. As tidal forces fall off as r_o^{-3} and the force of gravity falls off as r_o^{-2} we can conclude that there is no prospect of a primate satellite as described having any noticable effect on the Earth's tides or orbit. Even orbiting at its Roche limit the primate satellite would likely go unnoticed by the remaining inhabitants of Earth, except perhaps whenever a primate body broke off, reentered the Earth's atmosphere at orbital speeds, and created a disturbingly biological shooting star.

References

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