What Sets the Time for Tides to Stop a Rotation Is Not the Other Body's Mass but the Distance

— The timescale for locking goes as the sixth power of the distance and as the inverse square of the primary's mass — the separator is distance acting as a sixth power against mass acting as an inverse square — [Paper 815]

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— *From thinking to syncing.* —

Abstract

The Moon always turns the same face to the Earth.Within one standard timescale formula, it is compared whether the time to reach that state is set by the other body's mass or by the distance.No new theorem or law is claimed. First, distance acts as a sixth power——twice the distance multiplies the time by $\mathbf{64.000000}$, three times by $\mathbf{729.000000}$, and half by $\mathbf{0.015625}$ (Section 2). **Second, and this is the core. Mass acts only as an inverse square ——doubling the primary's mass multiplies the time by just $\mathbf{0.250000}$, losing to distance by orders of magnitude** (Section 2). **Third, so the Sun, though heavier, is slower——the Sun is $\mathbf{3.330543} \times 10^5$ times more massive than the Earth but $\mathbf{389.177940}$ times farther, and the timescale for locking the Earth's spin is $\mathbf{5.164221} \times 10^4$ times that for the Moon** (Section 3). **Fourth, the gap straddles the age of the universe——the Moon's figure, $\mathbf{4.010492} \times 10^7$ years, is shorter than 1.38×10^{10} years, and the Sun's, $\mathbf{2.071107} \times 10^{12}$ years, is longer** (Section 3). **Fifth, the absolute years are only representative——they rest on $Q = 100$ and $k_2 = 0.02$; the ratios are the firmer part** (Section 4). **Sixth, the separator is distance as a sixth power against mass as an inverse square——"a heavier partner locks you faster" can be said only once the distances are matched** (Section 4). **Keywords**: tidal locking, synchronous rotation, power of distance, dissipation, timescale formula, representative values.

Scope of this paper (scope note): **No new theorem or law is claimed——tidal braking of a spin, the strong dependence of the locking time on distance, and the Moon's synchronous rotation are all known.Only a timescale formula is used ——the form $t \approx \omega a^6 IQ/(3GM^2 k_2 R^5)$ is used and neither derived nor refined.The absolute years are not claimed ——$Q = 100$, $k_2 = 0.02$ and an initial spin $\omega_0 = 10^{-4}$ are representative and vary greatly between bodies; the ratios are the firmer part.Resonances are not treated——cases where eccentricity matters (Mercury's 3 to 2) are not entered.Tidal heating is not treated——heat flow and internal structure are not the subject.Orbital evolution is not followed——the distance is held fixed for the comparison rather than allowed to change during locking.Relation to earlier papers**: **Paper 783 showed that where the tides end up is set by angular momentum alone and the time to get there by dissipation, and its scope note stated "dissipation is taken constant—only the simplest model, with the recession rate going as the $-11/2$ power of distance, is used"——this paper stands beside it: there the orbit receding, here the satellite's spin stopping, two quantities of the same tide.Paper 406 showed that seeing the same face is the evidence that the Moon rotates——there the locked result, here the time to reach it.**What is added is **comparing distance and mass inside one formula as a sixth power against an inverse square**, **counting how mass and distance pull in opposite directions for the Sun and the Moon**, **confirming that the two figures straddle the age of the universe**, and **placing the separator on distance versus mass**.

1. Notation and the Question

Setting: **let t be the time for a spinning body, braked by the tide of its partner, to reach the state where its spin matches its orbit.The standard timescale has the form**

$$t \approx \frac{\omega\, a^6\, I\, Q}{3\, G\, M^2\, k_2\, R^5}, \qquad I = 0.4\, m\, R^2$$

where a is the distance, M the partner's mass, m and R the spinning body's mass and radius, Q the dissipation and k_2 the tidal response.

Question: **is this time set by the partner's mass or by the distance?**

2. Moving Distance and Mass Separately

Computation 2.1: **with the Moon about the Earth, only the distance was changed.**

distance	ratio of times	a sixth power would give
0.5 times	**0.015625**	**0.015625**
1 time	**1.000000**	**1.000000**
2 times	**64.000000**	**64.000000**
3 times	**729.000000**	**729.000000**

Computation 2.2: **at the same distance, only the partner's mass was changed.**

partner's mass	ratio of times	an inverse square would give
0.5 times	**4.000000**	**4.000000**
1 time	**1.000000**	**1.000000**
2 times	**0.250000**	**0.250000**

> **Observation 2.3**
>
> **this is the core. Distance acts as a sixth power, mass only as an inverse square.Doubling the distance multiplies the time by 64.000000, while doubling the mass multiplies it by 0.250000——moved by the same factor, distance bites 256 times harder.**

3. Comparing the Sun and the Moon

Computation 3.1: **the Moon about the Earth and the Earth about the Sun were put into the same formula.**

pair	ratio of partner's mass	ratio of distance
Sun-Earth / Earth-Moon	**3.330543×10^5**	**389.177940**

timescale for locking	years
the Moon (about the Earth)	4.010492×10^{7}
the Earth (about the Sun)	2.071107×10^{12}
ratio	5.164221×10^{4}

Observation 3.2

the Sun, though heavier, is slower.The mass ratio 3.330543×10^{5} pulls the time down, but the distance ratio 389.177940 enters as a sixth power, leaving the Sun 5.164221×10^{4} times slower——the inverse square of mass loses to the sixth power of distance.

Observation 3.3

the gap straddles the age of the universe.The Moon's figure, 4.010492×10^{7} years, is shorter than 1.38×10^{10} years; the Sun's, 2.071107×10^{12} years, is longer——between these two numbers lies the reason the Moon is locked and the Earth's day is not locked to the Sun.

4. The Separator

Observation 4.1

the separator is distance as a sixth power against mass as an inverse square."A heavier partner locks you faster" holds only at matched distances——with distances unmatched, five orders of magnitude in mass lose to two and a half in distance.

Observation 4.2

the ratios are the firmer part.The years themselves rest on representative values $Q = 100$ and $k_2 = 0.02$ and move by orders of magnitude between bodies——what is claimed here is the direction and the powers, not the years.

Observation 4.3

placed beside Papers 783 and 406.Paper 783 showed that where the tides end up is set by angular momentum and the time by dissipation——there the receding orbit, here the stopping spin, two quantities of the same tide.Paper 406 showed that seeing the same face is the evidence of rotation——there the locked result, here the time to reach it.

Observation 4.4

what is not said.Resonances (Mercury's 3 to 2), tidal heating, orbital evolution and internal structure are not treated——what is shown is that within one formula distance beats mass.

5. Census and Closing

1. **twice the distance: 64.000000** (Computation 2.1): **a sixth power.**
2. **three times: 729.000000** (Computation 2.1): **as the power says.**
3. **half: 0.015625** (Computation 2.1): **closer is faster.**
4. **double the mass: 0.250000** (Computation 2.2): **the core; an inverse square.**
5. **mass ratio 3.330543×10^{5}** (Computation 3.1): **the Sun is heavy.**
6. **distance ratio 389.177940** (Computation 3.1): **the Sun is far.**
7. **Moon: 4.010492×10^{7} years** (Computation 3.1): **shorter than the universe.**
8. **Earth: 2.071107×10^{12} years** (Computation 3.1): **longer.**
9. **ratio 5.164221×10^{4}** (Observation 3.2): **heavier yet slower.**
10. **distance or mass** (Observation 4.1): **the separator; Papers 783, 406.**

Closing: **What sets the time for tides to stop a rotation is not the other body's mass but the distance.Moving the same Moon to twice the distance multiplies the time by 64.000000 and to three times by 729.000000, while doubling the primary's mass multiplies it by only 0.250000——distance enters as a sixth power and mass only as an inverse square.So although the Sun is 3.330543×10^{5} times more massive than the Earth, being 389.177940 times farther leaves the locking timescale for the Earth's spin at 5.164221×10^{4} times the Moon's, namely 2.071107×10^{12} years ——the Moon's 4.010492×10^{7} years is shorter than the age of the universe and the Sun's is longer.The separator is distance as a sixth power against mass as an inverse square.Placed among the earlier papers——standing beside**

Paper 783's tide (there the receding orbit) and adding, to Paper 406's locked result, the time it takes.To be honest ——the years rest on representative Q and k_2, and the claim is the ratios.

References

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