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P2_10 Leap Year? Get out of Here! Part 2

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Abstract

The aim of this paper was to determine by how much Earth's rotation would have to slow down so that each orbital year was exactly 365 days, which would therefore remove the leap year. This was found to require the period of Earth's rotation to decrease by 0.27% which corresponds to removing 1.1763×10^{27} J of energy from the Earth. It was determined that this is not feasible because current energy production is insufficient, and also because we would have no mechanism of applying this force to the Earth even if we did meet the energy requirements.

Introduction

The Gregorian calendar is the standard calendar used across most of the world, however, it has to make some exceptions to account for leap years. Leap years occur because the Earth's rotational period, the measurement for a day, and the Earth's orbital period, the measurement of a year, are not exact multiples of each other. If they were exact multiples of each other then there would be a way to construct a calendar that was the same each year, without any leap years. As such, this paper aims to explore the physics of changing the rotational period of the Earth to make it an exact multiple of the year to remove the leap year from the calendar.

Theory

The angular velocity of the Earth can be calculated using:

$$\omega = \frac{2\pi}{T} \quad (1)$$

where T is the rotational period. The energy of the Earth's orbit for a given angular velocity, corresponding to its period, is given by the

kinetic rotational energy of a spherical body [1]:

$$E_{\text{Earth}} = \frac{1}{2}I\omega^2 \quad (2)$$

where I is the Moment of Inertia, and ω is the angular velocity value of the Earth's orbit around its axis.

The amount of energy required to slow the Earth's rotation to remove the leap year can be calculated by finding the difference in the kinetic rotational energy of the Earth before and after changing the period. The energy difference is given by:

$$\Delta E = E_i - E_f \quad (3)$$

Results

The Earth's current rotational period for a full stellar day takes $T_i = 86164\text{s}$ [2]. Substituting this result into Eq. (1) gives an angular velocity of $\omega_i = 7.2921 \times 10^{-5} \text{ rad s}^{-1}$. For the Earth day to be an exact multiple of the year, the rotational period should be equal to $T_f = 86400\text{s}$, which is the conventional measurement of the time elapsed in a full day. The new angular velocity of the Earth when substituting this period

value into Eq. (1) is $\omega_f = 7.2722 \times 10^{-5} \text{ rad s}^{-1}$. As such, the Earth's rotation is required to be slowed by 0.27% to remove the leap year.

The Moment of Inertia for the Earth is $I = 8.117 \times 10^{37} \text{ kg m}^2$ [3]. The energy for the Earth's current rotational period, E_i , is found by substituting ω_i and I into Eq. (2). This is calculated to be $E_i = 2.1581 \times 10^{29} \text{ J}$. The energy for the Earth's rotational period after removing the leap year, E_f , is found by substituting ω_f and I into Eq. (2) which calculates $E_f = 2.1463 \times 10^{29} \text{ J}$.

The energy values E_i and E_f are substituted into Eq. 3 to find the energy difference. This was found to be $\Delta E = 1.1763 \times 10^{27} \text{ J}$.

Discussion

The energy value required to slow the Earth's rotation enough to remove the leap year is found to be $\approx 10^3$ smaller than the energy found by directly altering the Earth's orbit around the Sun to remove the leap year ($\approx 1.22 \times 10^{30} \text{ J}$ [4]). However, this is still orders of magnitude larger than any energy we are currently capable of producing - current yearly energy demand of the world is $5.8 \times 10^{20} \text{ J}$ [5], which is a factor of 2×10^6 smaller than the energy required. At this rate of yearly energy usage, it would take 2 million years to produce enough energy to remove the leap year, assuming that all the energy produced on Earth is dedicated to this task and that there are no energy losses in applying this energy. This highlights how removing the leap year is not practical, even when this method is more efficient than altering the orbit around the Sun. Finally, even if we assume that we could readily produce this much energy, applying it would be difficult. One proposal might be to use thrusters on the Earth's surface acting in the opposite direction to the axis of rotation (see Fig. 1). However, this idea is fundamentally flawed as the exhaust of the thrusters will be emitted into the atmosphere and counteract the effects of the rockets. This highlights how exceptionally large the Earth is and how little humans are capable of effecting planetary system with current energy production.

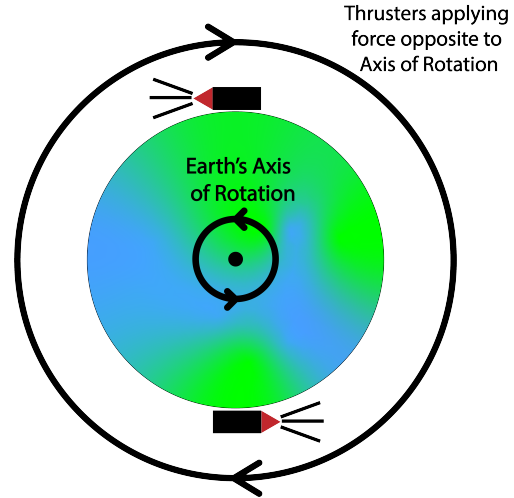


Figure 1: Diagram showing how boosters would attach to Earth to slow its rotation to remove the leap year.

Conclusion

It was found that the period of Earth's rotation must decrease by 0.27% to remove the leap year which corresponds to removing $1.1763 \times 10^{27} \text{ J}$ of energy from the Earth. It was then determined that this is not feasible because current energy production is insufficient, and also because we would have no mechanism of applying this force to the Earth even if we did meet the energy requirements.

References

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