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P3_9 Stopping the Earth

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Abstract
This paper examines the possibility of stopping or slowing the Earth's natural rotation by considering the Earth's angular momentum via human methods. This was done by considering the angular momentum generated by humans and vehicles moving around the equator. The Earth's rotation period was found to be 0.153ns shorter if all living humans ran, and 3.70ns shorter if all vehicles drove around the equator.

Introduction

The length of a day controls many aspects of our lives from the hours we sleep to the climate we have. The Earth's rotation rate, which is governed by its angular momentum dictates the length of the day. This paper investigates whether angular momentum of the human race running around the equator could slow down, or even stop, the Earth's rotation rate.

Theory

The angular momentum of the Earth will be calculated first. The angular momentum of a body is,

$$L = I\omega, \tag{1}$$

where I is the moment of inertia and ω is the angular velocity. Angular momentum is conserved, therefore for the Earth to stop spinning, i.e. $\omega \to 0$, an opposing angular momentum must be applied, so that the net result is 0. The angular velocity is;

$$\omega = \frac{2\pi}{T} \tag{2}$$

where T is the the time period of the rotation.

The Earth, which can be modelled as a solid sphere, has a moment of inertia [1] of

$$I_E = \frac{2}{5} M_E {R_E}^2, \tag{3}$$

where M_E is the mass of the Earth and R_E is the equatorial radius. Combining these equations, gives the angular moment of the Earth;

$$L_E = \frac{2}{5} M_E {R_E}^2 \frac{2\pi}{T_E} \tag{4}$$

The opposing angular momentum could be generated by having every human on Earth moving in a straight line around the equator, exerting a torque on the Earth to oppose its rotation. An approximation that corresponds to this would be if the moving humans are assumed to be moving around a thin ring around the equator. This can be modelled as a thin-walled hollow cylinder [1], with the radius the same as that of the Earth. This moment of inertia is,

$$I_P = M_P {R_E}^2 \tag{5}$$

and the angular momentum generated by the population moving is therefore,

$$L_P = M_P R_E v_p \tag{6}$$

where $v_p = R_E 2\pi/T_p$ is the linear speed of the motion of the people.

Equalling the angular momentums together,

$$\frac{2}{5} M_E {R_E}^2 \frac{2\pi}{T_E} = M_P R_E v_p. \tag{7}$$

If $L_E \neq L_P$, a non-zero resultant angular momentum will occur,

$$L_R = L_E - L_P = I_E \omega_R \tag{8}$$

where ω_R is the resultant angular velocity.

Results

The mass and equatorial radius of the Earth, are well documented constants [2], with values $5.97 * 10^{24} kg$ and $6378 km$ respectively. The population on Earth was estimated to be $7.12 * 10^9$ people [3] and the average body mass $62 kg$ [4]. The sidereal day, which the actual rotation rate of the Earth is 23.93 hours.

Using these values, it was calculated that the velocity this number of people would have to travel at around the equator would be to counteract the Earth's rotation is $2.52 * 10^{15} ms^{-1}$. If instead, all the cars on Earth, taken as $1.015 * 10^9$ [5] moved around the Earth's equator in a similar manner, and assuming the average mass of a car is $1500 kg$, the speed they would need to travel at is $7.3 * 10^{14} ms^{-1}$. Clearly, as this value is many magnitudes faster than the speed of light, the rotation of the Earth cannot be stopped by human or vehicular movement. This is due to the relatively small amount of mass that these make up.

However, using equation (8) it is possible to calculate how much shorter the day would be if a situation such as the one described in this report was carried out. If all humans on Earth were running at $10mph$, the day would be $0.153ns$ shorter. If all cars travelled at $70mph$, the day would $3.70ns$ shorter.

Conclusion

This analysis shows that it is not possible for humans to stop the Earth from rotating, either by moving around the equator themselves or in their cars. The change that either of these methods can have on the Earth's rotational rate is on the order of nano-seconds. This is due to the relatively low mass of these methods consist of compared to the Earth's mass.

References

[1] `http://www.engineeringtoolbox.com/moment-inertia-torque-d_913.html` accessed on 12/11/2013.
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