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Research Article

The Recurrence Inversion of the rotating objects at the Space Stations is the Gyroscopic Effect.

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Abstract

The space flights of the astronauts discovered a new physical phenomenon that is recurrence inversions of the rotating objects at the condition of weightlessness. This physical effect is an object of stare studying by scientific researchers of the entire world. They published only a dozen manuscripts with approximated and numerical models and assumptions because of complex problems. The analytical approaches of the new gyroscope theory enabled the description of the physics of the phenomenon of the rotating object in the weightless conditions of space flights. On the rotating object, at the free flight, are acting the inertial forces generated by its circular motions around the earth and its rotating mass.

Keywords: Inertial toque; Gyroscope theory; Mathematical model; Inversion

Introduction

The flights of rotating objects at the condition of weightlessness have manifested the phenomena of their recurrence inversions. The world physicists study this amazing effect of rotating objects and propose several approximated theories and numerical models which do not describe the origin of their recurrence inversions [1, 3]. The several dozen manuscripts attempted to describe the phenomena of the recurrence inversions of the rotating objects at orbitals flights and showed the sophistication of the problem that is interested only in persistent researchers [4, 5]. Analysis of their analytical approaches and methods for solutions shows the utilization of the known mathematical models and intuitive assumptions as for the spinning top. They used the basic rules of classical mechanics that are the angular momentum, kinetic energy, and the tennis racket theorem [6, 9].

The deep study of the orbital flight of the rotating object and its recurrence inversions has shown the effect of the combined action of the inertial torques on the objects. The basic rules of classical mechanics [6, 9] and the new gyroscope theory [10] describe the recurrence inversions of the rotating objects in space. The recurrence inversion of the rotating object is the result of the combined effect of two components of the inertial torques at the conditions of the space flight. The first is the torques produced the circular motion of the rotating object that is external, and its rotating mass generates the second ones that are interrelated. On the rotating object at the space flight are acting the same torques that manifest the gyroscopic effects.

Methodology

The rules of classical mechanics and the gyroscope theory plan the analytical model for the recurrence inversions of the rotating object at the space flight. The rotating object moves with the constant tangential velocity V around the earth by the radius R from its center. The circular motion of the object produces the inertial torque acting on one which expression is [6-9]:

$$T = (J_o + mR^2)\varepsilon \qquad (1)$$

where T is the torque; $J = J_o + mR^2$ is moment of inertia of the object defined by the parallel axis theorem; m is the mass of the object, J_o is the moment of inertia of the object about own center of mass; ε is the angular acceleration of the object.

This inertial torque is fundamental in the classical mechanics. All freely rotating objects always turn about their center mass with the angular velocity of their rotation about the fixed point. The confirmation of this statement is the moon's motion that always shows its one side toward to the earth. From this, the inertial torque acting on the disc that moves around the earth is:

$$T = J\omega_o^2 = \left(\frac{mr^2}{2} + mR^2\right)\left(\frac{V}{R}\right)^2 = m\left(\frac{r^2}{4} + R^2\right)\left(\frac{V}{R}\right)^2 \qquad (2)$$

Where J is the moment of inertia of the disc about the center of earth; m is the mass of the disc; r is the radius of the disc; R is the orbital radius of the disc flight; $\omega o = V/R$ is the angular velocity of the disc about the earth›s center; other parameters are as presented above.

The gyroscope theory formulates by the several torques produced by the mass of the rotating disc that interrelated by the defined ratio of its angular velocities around axes of rotation [10, Chapter 4]. The action of the torques presented above explains the physics and enables presenting the analytical model of the recurrence inversion of the rotating disc at the space stations.

The mathematical model for th recurrence inversion of the rotating object is considered for the disc located horizontally in the space flight and the action of the external torque T (Eq. 2) (Fig. 1). The disc rotates with the velocity ω in the counterclockwise direction around axis oz that inclined on the angle ϕ to the line of its flight. The inertial torques produced by the rotating mass of the disc and the ratio of its angular velocities of the around axes are presented in Table 1[10, Chapter 5].

Type of the torque generated by	***Equation, kg·m²/s²***
Centrifugal forces Inertial forces	$T_{ct} = T_{in} = \frac{2}{9}\pi^2 J\omega\omega_x$
Coriolis forces	$T_{cr} = \frac{8}{9}J\omega\omega_i$
Change in angular momentum	$T_{am} = J\omega\omega_i$
Resistance torque $T_r = T_{ct} + T_{cr}$	$T_r = \left(\frac{2\pi^2 + 8}{9}\right)J\omega\omega_x$
Precession torque $T_p = T_{in} + T_{am}$	$T_p = \left(\frac{2\pi^2 + 9}{9}\right)J\omega\omega_x$
The dependency of angular velocities of the disc rotation about axes oy and ox, degrees/s	
$\omega_y = (4\pi^2 + 17)\omega_x$	

Table 1: Equations of the inertial torques acting on the rotating disc.

Where *J* is the moment of inertia of the rotating disc; ω is the angular velocity of the disc, and ω_i is the angular velocity of the disc about axis *i*.

The mathematical model for the rotating disc motions and the recurrence inversions at the space station is formulated by the simultaneous action of the torques (Eq. 2 and Table 1). The torques and motions of the rotating disc before the first (a) and second (b) inversion are represented in Fig. 1.

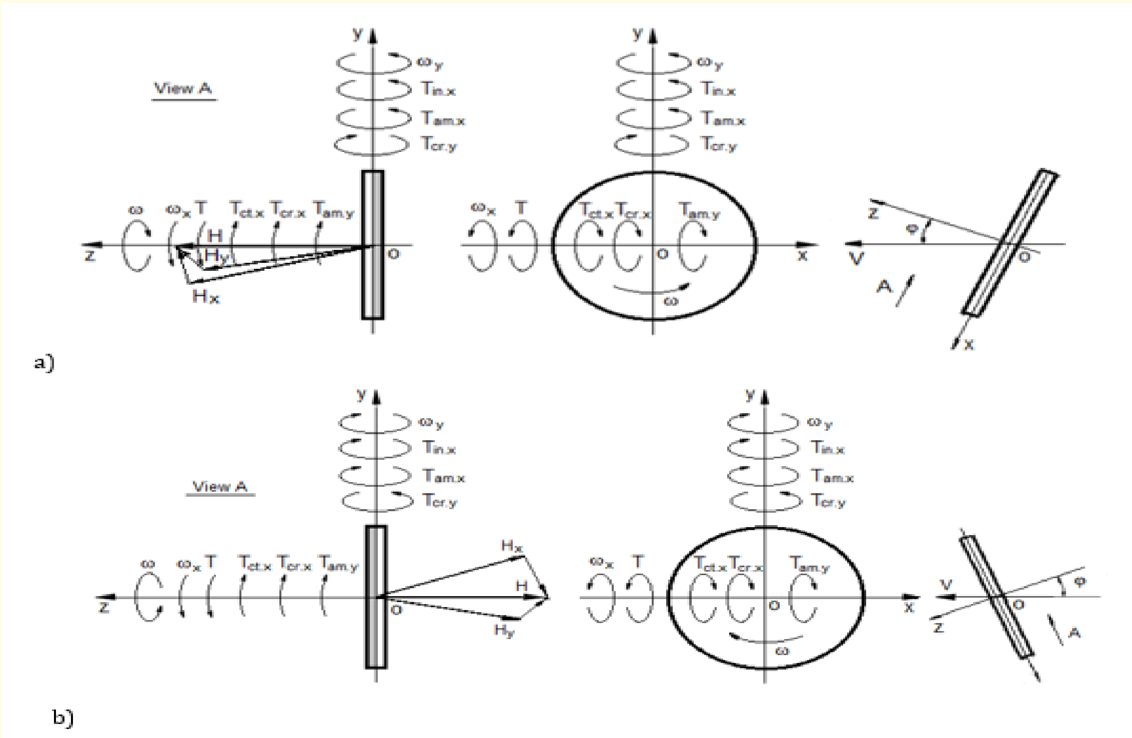

Figure 1: The torques and motions acting on the rotating disc in the space station before the first (a) and second (b) inversion.

The analytical model for the motions of the rotating disc around two axes are presented by the Euler's differential equations [10, Chapter 6]:

$$J_x \frac{d\omega_x}{dt} = T\cos\varphi - T_{ctx} - T_{crx} - T_{amy} \qquad (3)$$

$$\pm J_y \frac{d\omega_y}{dt} = T_{inx} + T_{amx} - T_{cry} \qquad (4)$$

$$\pm \omega_y = (4\pi^2 + 17)\omega_x \qquad (5)$$

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Where ω_x and ω_z is the angular velocity of the disc about axes *ox* and *oy,* respectively; *t* is the time; $T_{ctx,}$ $T_{crx,}$ T_{cry}, T_{inx}, $T_{amx,}$ and T_{amy} are the inertial torques generated by the rotating mass of the disc about axes *ox* and *oy,* respectively (Table 1); φ is the angle of the inclination of the rotating disc axle to the line of its flight (Fig. 1) on the horizontal plane *xoy*; J_y and J_x are the moments of inertia of the disc about axes *oy* and *ox,* respectively; the sign (±) belongs to the first and second inversion, respectively.

Substituting the torques (Eqs. 2 and Tale 1) into Eq. (3) yields the following:

$$J_x \frac{d\omega_x}{dt} = m\left(\frac{r^2}{4} + R^2\right)\left(\frac{V}{R}\right)^2 \cos\varphi - \frac{2}{9}\pi^2 J\omega\omega_x - \frac{8}{9}J\omega\omega_x - (4\pi^2 + 17)J\omega\omega_x \qquad (6)$$

Equation (6) is simplified:

$$J_x \frac{d\omega_x}{dt} = m\left(\frac{r^2}{4} + R^2\right)\left(\frac{V}{R}\right)^2 \cos\varphi - \left(\frac{38\pi^2 + 161}{9}\right)J\omega\omega_x \qquad (7)$$

where all components are as defined above.

Solving Eqs. (7) and (5) yields the angular velocity of the disc about axis *ox* and *oy,* respectively. The disc rotates in the counterclockwise and clockwise direction respectively, i.e., manifests the cyclic inversions. Such rotation presents the harmonic dumped oscillation process. The angular velocity ω_y of the rotating disc and frequency of the oscillation depends on the angle ϕ of axis inclination (Fig. 1). The rotating disc axis of horizontal and perpendicular (cos 90° = 0) to the line of the flight does not produce the precession torque and the inversion. The same equations are described the vertical or intermediate angular location of the disc axis.

Results and discussion

The recurrence inversion process of the rotating object at the space station is the result of the action of the inertial torques generated by its rotating mass and the flight around the earth. The torques acting on the rotating object at the space station are now in classical mechanics. The recurrence inversion of the rotating object is the gyroscopic effects with and damped harmonic oscillations. The mathematical model describes the physics of the recurrence inversion of the rotating object at the space station.

Conclusion

The tests of the rotating object at the space station showed its recurrence inversions that were an unsolved problem for the physicists. The methods and analytical approaches of the gyroscope theory can solve all problems based on the action of the inertial torques produced by the rotating objects. The recurrence inversions of the rotating objects are manifestations of gyroscopic effects at the space station. The physics and solution of the recurrence inversions of the rotating object at the free flight present a good example of the educational process.

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Volume 1 Issue 1 September 2021