УДК 531.381

EVOLUTION OF MOTIONS IN A RESISTIVE MEDIUM OF A GYROSTAT SUBJECTED TO CONSTANT BODY-FIXED TORQUES

Dmytro Leshchenko, Tetiana Kozachenko

Odessa State Academy of Civil Engineering and Architecture

leshchenko_d@ukr.net, kushpil.t.a@gmail.com

A satellite or a spacecraft in its motion about the center of mass is affected by the torques of forces of various physical natures. It is influenced by the gravitational, aerodynamic torques, the torques due to the light pressure, and the torques due to the motions of masses inside the body. These motions may have various causes, for example, the presence of fluid in the cavities in the body (for example, liquid fuel or oxidizer in the tanks of a rocket). Therefore, there is a necessity to study the problems of the dynamics of bodies with cavities containing a viscous fluid, to calculate the motion of spacecrafts about the center of mass, as well as their orientation and stabilization. The mentioned torques, acting on the body, are often relatively small and can be considered as perturbations. It is natural to use the methods of small parameter to analyze the dynamics of rigid bodies under the action of applied torques. We apply the Krylov – Bogolubov asymptotic averaging method.

The problems of rigid body dynamics with cavities containing a viscous fluid are significantly more difficult than in the case of an ideal fluid. An important contribution to the solution of these problems has been made in [1]. These studies showed that solving the problems of the dynamics of the rigid body with viscous fluid in the cavity can be separated into two parts: the hydrodynamic and dynamic ones, which represents a considerable simplification of the original problem. An asymptotic solution was obtained describing the evolution of the motion of a body having a cavity with a fluid of high viscosity over a long time interval.

The motion of a close to the dynamically spherical rigid body with a cavity filled with a viscous fluid at a low Reynolds number was investigated in [2]. Qualitative and quantitative results of motion in a resistive medium of a nearly dynamically spherical rigid body with a cavity containing fluid of high viscosity were studied in [3]. In paper [4], the motion about the center of mass of a nearly dynamically spherical rigid body with a cavity filled with a fluid of high viscosity and subjected to constant body-fixed torques was considered.

We investigated the motion about its center of mass in a resistive medium of

http://iapmm.lviv.ua/mpmm2023/materials/mm07_13.pdf

a nearly dynamically spherical rigid body with a cavity filled with a viscous fluid at small Reynolds numbers, subjected to constant body-fixed torque which is described by the system of differential equations, considering the asymptotic approximation of the torquess of the viscous fluid in the cavity. The determination of the motions of forces acting on the body from the side of the viscous fluid in the cavity was proposed in [1]. We obtained the system of equations of motion in the standard form which was refined in square approximation by a small parameter. The Cauchy problem for a system determined after averaging was analyzed. The evolution of the motion of a rigid body under the action of small internal and external torques of forces is described by the solutions obtained as a result of asymptotic, analytical, and numerical calculations over an infinite time interval.

These results made it possible to analyze the motions of artificial satellites and celestial bodies under the influence of small internal and external torques.

1. *Chernousko F.L., Akulenko L.D., Leshchenko D.D.* Evolution of motions of a rigid body about its center of mass. – Cham: Springer International Publishing, 2017. – 241 p.
2. *Akulenko L.D., Leshchenko D.D., Paly K.S.* Perturbed rotational motions of a spheroid with cavity filled with a viscous fluid // Proc. IMechE Part C: Journal of Mechanical Engineering Science. – 2021. – **235**, No. 20. – P. 4833–4837.
3. *Leshchenko D., Ershkov S., Kozachenko T.* Evolution of rotational motions of a nearly dynamically spherical rigid body with cavity containing a viscous fluid in a resistive medium // International Journal of Non-Linear Mechanics. – 2022. – **142**, No. 3. – 103980.
4. *Leshchenko D., Ershkov S., Kozachenko T.* Perturbed rotational motions of a nearly dynamically spherical rigid body with cavity containing a viscous fluid subject to constant body fixed torques // International Journal of Non-Linear Mechanics. – 2023. – **148**, No. 3. – 104284.

ЕВОЛЮЦІЯ РУХІВ В СЕРЕДОВИЩІ З ОПОРОМ ГІРОСТАТА ПІД ДІЄЮ ПОСТІЙНИХ МОМЕНТІВ В ЗВ'ЯЗАНИХ З ТІЛОМ ОСЯХ

На супутник або космічний апарат у русі відносно центра мас діють моменти сил різної фізичної природи. Це гравітаційні, аеродинамічні моменти, а також моменти, обумовлені рухом деяких мас в тілі. Ці моменти є відносно малими і можуть розглядатися як збурення. Задачі динаміки твердого тіла з порожнинами, що містять в'язку рідину, складають більші труднощі, ніж у випадку ідеальної рідини. Розглядається рух відносно центра мас в середовищі з опором близького до динамічно сферичного твердого тіла з порожниною, заповненою в'язкою рідиною при малих числах Рейнольдса під дією постійного моменту в зв'язаних з тілом осях, який описується системою диференційних рівнянь з урахуванням в асимптотичному наближенні моментів сил в'язкої рідини в порожнині тіла. Отримано систему рівнянь руху в стандартній формі, уточнену в квадратичному наближенні за малим параметром. Проаналізовано задачу Коші для системи, визначеної після усереднення. Еволюція руху твердого тіла під дією таких внутрішніх і зовнішніх моментів сил описується розв'язками, одержаними в результаті асимптотичних, аналітичних і чисельних розрахунків на нескінченному інтервалі часу.