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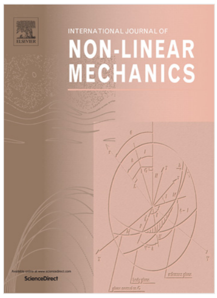

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ACCEPTED MANUSCRIPT

Analytical Solutions for Dynamics of Dual-Spin Spacecraft and Gyrostat-Satellites under Magnetic Attitude Control in Omega-Regimes

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Abstract: - The attitude dynamics of a dual-spin spacecraft (a gyrostat with one rotor) with magnetic actuators attitude control is considered in the constant external magnetic field at the presence of the spacecraft's own magnetic dipole moment, which is created proportionally to the angular velocity components (this motion regime can be called as "the omega-regime" or "the omega-maneuver"). The research of the dual-spin spacecraft angular motion under the action of the magnetic restoring torque is fulfilled in the generalized formulation close to the classical mechanics' task of the heavy body/gyrostat motion in the Lagrange top. Analytical exact solutions of differential equations of the motion are obtained for all parameters in terms of elliptic integrals and the Jacobi functions. New obtained analytical solutions can be classified as results developing the classical fundamental problem of the rigid body and gyrostat motion around fixed point. The technical application of the omega-regime to the angular reorientation of the spacecraft longitudinal axis along the angular momentum vector is considered.

Key-Words: Spacecraft; Satellite; Gyrostat; Dual-Spin Spacecraft; Rigid Body Dynamics; Explicit Exact Solutions; Elliptical Integrals; Jacobi Elliptic Functions; Generalization; Lagrange Top; Omega-Regime

Introduction

An analytical investigation of the angular motion of rigid bodies systems together with its practical applications in the field of the attitude dynamics of spacecraft/satellites is one of the important actual scientific problems of the fundamental mechanics and the space flight dynamics, including classical tasks of the rigid body angular motion [1, 2], modern developments of these classical tasks with applications [3-7], as well as the rigid bodies and spacecraft regular and chaotic dynamical aspects [8-18]. As it is well known, analytical solutions for the system dynamical parameters allow to completely describe the system motion and to predict its time-evolutions and, moreover, analytical solutions/dependencies can be used for the parametrical synthesis of the spacecraft (SC) dynamics.

In this work the analytical solutions for the motion dynamics of the small SC (micro-/nano-satellites) with a magnetic control system are obtained. Besides the magnetic actuators (such as magnetic coils and/or torque rods), the SC investigated in the research contains one coaxial rotor/reaction-wheel with its own constant longitudinal angular momentum (Δ), so it is possible to consider the SC as the dual-spin spacecraft (DSSC) with the magnetic attitude control. The DSSC motion is considered in the constant external magnetic field. The own dipole moment of the DSSC is created by the magnetic attitude control system in the form proportional to the angular velocity components (this motion mode can be called as "the omega-regime"). The constancy of the external magnetic field in this research is conditioned by the consideration of the angular motion of the DCCS

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