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SMALL SATELLITE MISSIONS SYMPOSIUM (B4)
Small Satellites Potential for Future Integrated Applications and Services (4)

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# CHAOS IN THE ROTATIONAL MOTION OF A MAGNETIC SPACECRAFT IN POLAR CIRCULAR ORBIT WITH INTERNAL DAMPING DUE TO MAGNETIC HYSTERESIS

**Abstract**

Magnetic attitude control is the most widely used method for stabilizing small satellites. A magnetic torque generated by the interaction between Earth's magnetic field and a permanent magnet placed inside the spacecraft body tends to turn the satellite parallel with the local field. This causes oscillations in the attitude of the satellite. The oscillation period depends on the strength of the external field and the magnetic and mechanical properties of the satellite. If the external field along the trajectory - due to the orbiting motion of the spacecraft - varies considerably within that characteristic period of time, it can be shown, that the pitch motion of the satellite can act analogously to a widely studied example of chaotic dynamics: the magnetic rotator with a sinusoidal external excitation.

Transient chaos in the rotation of such satellites was already confirmed by observational data, and various efforts were carried out to study the possibilities of both active and passive attitude control in similar setups. One of the easiest mechanisms to control this chaotic rotation can be based on some dissipative element. For example, if the ferromagnetic material of the satellite had a considerable hysteresis in the magnetic field experienced along the orbital path, this hysteresis term can act as a drag in the equations of rotational motion. The hysteresis can dissipate torque and stabilize the attitude of the satellite.

In the present work we carried out various numerical simulations for a rotationally symmetric satellite in a polar circular Earth orbit. We discussed how the transition from linear to nonlinear behavior occurs in terms of appropriately chosen dimensionless combinations of the mechanic and magnetic parameters. We performed a wide-range analysis of the dependence of the maximal Lyapunov-exponent on these parameters, and gave the optimal range for spacecraft stabilization in the parameter space. These results can be widely used for the design of attitude control systems based on this classical setup of permanent magnets and hysteresis rods of future magnetically stabilized picosatellites.