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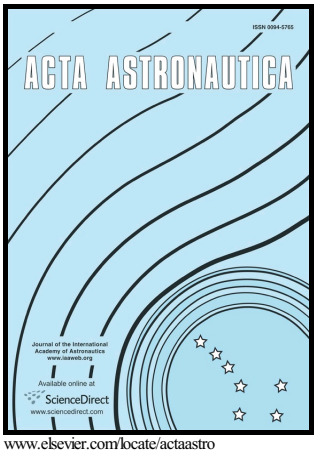

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Nonlinear model and attitude dynamics of flexible spacecraft with large amplitude slosh

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Abstract

This paper is focused on the nonlinearly modelling and attitude dynamics of spacecraft coupled with large amplitude liquid sloshing dynamics and flexible appendage vibration. The large amplitude fuel slosh dynamics is included by using an improved moving pulsating ball model. The moving pulsating ball model is an equivalent mechanical model that is capable of imitating the whole liquid reorientation process. A modification is introduced in the capillary force computation in order to more precisely estimate the settling location of liquid in microgravity or zero-g environment. The flexible appendage is modelled as a three dimensional Bernoulli-Euler beam and the assumed modal method is employed to derive the nonlinear mechanical model for the overall coupled system of liquid filled spacecraft with appendage. The attitude maneuver is implemented by the momentum transfer technique, and a feedback controller is designed. The simulation results show that the liquid sloshing can always result in nutation behavior, but the effect of flexible deformation of appendage depends on the amplitude and direction of attitude maneuver performed by spacecraft. Moreover, it is found that the liquid sloshing and the vibration of flexible appendage are coupled with each other, and the coupling becomes more significant with more rapid motion of spacecraft. This study reveals that the appendage's flexibility has influence on the liquid's location and settling time in microgravity. The presented nonlinear