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ASTRODYNAMICS SYMPOSIUM (C1)
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Author: Dr. Martin Lara
Spain, mlara0@gmail.com

Prof. Sebastián Ferrer
University of Murcia, Spain, sferrer@um.es

NEW ELEMENTS FOR THE EFFICIENT PROPAGATION OF ATTITUDE DYNAMICS

Abstract

Attitude dynamics of artificial satellites may be studied in different representations, Euler angles or quaternions being popular ones, the selection of which depends mainly on its intended application to propagation, control or attitude determination.

The problem of attitude propagation is commonly approached numerically, with a variety of algorithms available, although analytical attempts have also been proposed. Perturbative schemes have been successful in the generation of numerical algorithms, but are also the common way of dealing with analytical methods. The Euler-Poinsot problem is taken as the unperturbed part and the other effects are taken as perturbations of the torque-free rotation. Among the perturbations, the gravity-gradient is usually the more relevant effect. Analytical approaches are also useful in stability studies, which are essential in attitude control.

The success of analytical perturbations strongly depends on the variables used. The accomplishment of KAM conditions for non-degeneracy is normally required, although degenerate variables may be useful in dealing with resonant motion. Besides, the variables used should be suited to the perturbation problem in order to ease the required formal computations.

Angular variables always show singularities in the description of the rigid-body motion, and redundant sets of variables (starting from Euler parameters) may be preferred. Nevertheless, the whole phase space may be covered using two different charts of angular variables. The more intuitive description of the attitude is provided by the Euler angles, but they do not reflect all the geometrical symmetries of the torque-free motion and other sets of variables may be chosen instead. After Andoyer variables were recalled and put in the arena by Deprit, new sets of variables based on them, or in their Fukushima's variant, have been proposed for dealing analytically with perturbed attitude motion.

We propose a new set of variables that enjoy several merits that, until our knowledge, are not found together in variables in the literature. On one side, they demonstrate that the topology of the triaxial rigid-body motion is equivalent to the axisymmetric case. On the other, they provide complete reduction of the Euler-Poinsot problem without need of resorting to the intricate formulation required by (classical) action and angle variables. Finally, they show an evident non-degeneracy that ensures their suitability for application to perturbed problems. We illustrate this suitability with an application to the attitude motion perturbed with the gravity-gradient torque, a case that is of interest for artificial satellites but also in other problems like asteroid dynamics.