Perturbation solutions of the rotation of rigid bodies close to principal axes of inertia under gravity gradient torque

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The orbit and attitude six degree-of-freedom propagation is known to be a difficult technical problem since the translational and rotational dynamics have notoriously different characteristic time scales. Hatten and Russell [1] proposed a hybrid scheme to deal with this problem, which essentially consists of numerically integrating the translational equations and approximating the rotational states via explicit solutions of the attitude equations. They exemplify the method using the closed-form solutions provided by Lara and Ferrer [3], that assume fast rotation of the body and involve handling special functions which are of difficult evaluation.

As an alternative, we propose solving the attitude equations based on a perturbation scheme, whose solution does not involve special functions and hence it requires shorter computational time. However, this approach requires to add assumptions on the initial rotating states of the body.

The attitude is written in Hamiltonian form as $\mathcal{H} = T + U$, where T is the Euler-Poinsot Hamiltonian and U is the gravity gradient torque. If we assume that the body rotates close to its principal axis of inertia, T can be arranged as a perturbation problem independently of the shape of the body, see [2]. This arrangement is used to obtain perturbation solutions of the rotation of the rigid body under gravity gradient.

This is a joint work with Martin Lara and Camilla Colombo.

References

[1] N. Hatten and R.P. Russell, A semi-analytical technique for six-degree-of-freedom space object propagation. Paper 17-376. In: *27th AAS/AIAA Space Flight Mechanics Meeting*, San Antonio, TX, February 2017.
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[3] M. Lara and S. Ferrer, Closed form perturbation solution of a fast rotating triaxial satellite under gravity-gradient torque. Cosmic Research 51 (2013), no. 4, 289–303.