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Author: Prof. Daniel Condurache
Technical University of Iasi, Romania, daniel.condurache@gmail.com

N-BODY PROBLEM IN NON-INERTIAL REFERENCE FRAME. APPLICATION TO FULL TWO-BODY STABILITY PROBLEM

Abstract

In this paper, some new results from the N-body problem in a non-inertial rotating reference frame are applied to the problem of two interacting rigid bodies (the full two-body problem), each with an arbitrary gravity field. Such a problem can serve as a model for the dynamics of a binary small-body system, such as an asteroid or a Kuiper belt object, especially during the initial stages of its evolution following a disruptive impact or planetary flyby. Based on proper orthogonal dual tensor and skew-symmetric tensor valued functions, related by the Poisson-Darboux equation, together with a differentiation operator, the connection between the derivative in a non-inertial frame and the derivative in the inertial frame is presented. A variant of the Sundman‘s inequality for N- body problem in the non-inertial reference frame is demonstrated. The specific interest concerns the differential equation of motion long-term stability of the binary against disruption (escape) or impact. Stability against disruption for this problem is Hill stability, and we find sufficient conditions for this stability and sufficient conditions for violation of this stability. The new first integrals allow offering a kinematic and geometrical visualization of the motion in the non-inertial reference frame. The new first integrals of the motion, in a larger sense, and a generalized potential energy function is introduced. For the two-body problem, the closed-form coordinate-free solution for the law of motion of each body with respect to the original frame is presented. In the N -body problem, stability against impact is often related to Lagrange stability which restricts both the positions and velocities of the bodies to be bounded. For interacting point masses, such a restriction guarantees that impact will not occur. However, impacts can occur with finite velocity for rigid bodies with distributed mass. New sufficient conditions for stability against impact in the full two-body problem are found.