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RE-DISCOVERING DZHANIBEKOV'S PHENOMENON USING NON-LINEAR DYNAMICS AND VIRTUAL REALITY.

Abstract

Vladimir Dzhanibekov is a Russian cosmonaut famous with his 5 space flights (making him the Champion in this category). During his fifth space flight, on 25-June-1985, he has discovered a spectacular (odd-looking or perceived by many as mysterious) phenomenon, when a spinning rigid body in its stable flight suddenly changed its orientation by 180 degrees and continued its flight backwards, simultaneously changing its direction of rotation to opposite!

It was even more amazing to realize, that this pattern of motion has been repeated in the periodic sequence. Similar experiments have been run on-board of the International Space Station. Observing these experiments in space, it could be clearly seen that the spinning object always rotates in the same direction relative to the observation camera (fixed to the "inertial" coordinates frame): that means that in the reference frame of the rotating handle the direction of rotation flips each time its orientation flips. In order to explain the Dzhanibekov's phenomenon, we firstly formulate the task employing the Euler's equations for an unconstrained rigid body with appropriate initial conditions, the resulting non-linear differential equations are then solved using MATLAB's classical Runge-Kutta "ode" solvers. Solutions are obtained for the range of combination of critical parameters and are presented in the systematic way, to see the influence of the studied parameters. Aiming to involve the University auditory, we then illustrate results, using 3D graphics and spectacular animations in Virtual Reality. In particular, we animate the motion of the spinning object in the augmented Virtual reality, where various 3D vectors, relevant to the mathematical formulation of the task (including angular momentum, angular velocity and their components) are superimposed on the rotating object. The peculiar dynamics of the tumbling rotating body is illustrated in the inertial and body coordinate systems.

The Dzhanibekov's phenomenon is seen as one of the best inspiring examples in dynamics, and its exploration and explanation, using the Virtual Reality augmented animations, facilitate introduction into the non-linear dynamics, attitude dynamics of spacecraft and may be useful for the University students, postgraduates and academics.