Dynamics of a Spinning Structure Subjected to a Uniform Pressure

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Abstract: Recently, a High performance, Enabling, Low-cost, Innovative, Operational Solar Sail (HELIOS) system has aroused a great deal of interests among scientists and engineers. A HELIOS system called heliogyro is a high-performance, spinning solar sail architecture that uses long (order of kilometers) reflective membrane strips to produce thrust from solar radiation pressure. Many researchers have presented various analytical approaches to investigating the dynamic behavior of the solar sail viwed as a spinning membrane under a uniform pressure. In their studies, a discrete set of lumped-mass system or a completely-continuous system is adopted for constructing the spinning membrane. In our present model, we first propose that the spinning structure can be treated as a discrete-continuous (hybrid) system. The spinning structure is comstructed by an elastic thin plate connected to a rotating rigid hub. A hybrid coordinate dynamical system is introduced and used for deriving the governing equations and the associated boundary conditions. The coupled system of ordinary and partial differential equations follows directly from spatial and time differentiation of various Lagrangian functionals. In other words, the use of this technique can provide an easier way to acquire the governing equations and the boundary conditions without doing the tedious system-specific variational arguments and integration by parts.

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