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Dynamics of a Spinning Rocket with Internal Mass Flow

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Abstract: One of the main simplifying assumptions made in the study of the attitude motions of a rocket-type variable mass system is that the motion of the fluid products of combustion relative to the rocket body, as these fluid particles exit the rocket's combustion chamber, remains symmetric with respect to the rocket axis, and the fluid particles have no transverse motion relative to the rocket body. This assumption brings about a tremendous simplification of the equations that govern the attitude motion of a rocket, and is thus very attractive. Yet, one recognizes that such an assumption becomes questionable if the rocket body is allowed to spin. This paper examines the validity of this common assumption. The paper attempts to reconstruct what is lost when this assumption is made, and quantifies the effects on attitude dynamics predictions. Results obtained show that this assumption is in fact reasonable. Although internal fluid whirling motion can cause deviations in spin rate predictions, the actual effects are not dramatic. There is a noticeable impact on the frequencies of the transverse angular velocity components, but the amplitude of the transverse angular velocity vector is largely unaffected.

Keywords: *Rockets; variable mass processes; attitude dynamics.*

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