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# ATTITUDE MOTION PLANNING FOR A SPIN STABILISED DISK SAIL

**Abstract**

While solar sails are capable of providing continuous low thrust propulsion, the size and flexibility of the sail structure poses difficulties to their attitude control. Rapid slewing of the sail can cause excitation of structural modes, resulting in flexing and oscillation of the sail film and a subsequent loss of performance and decrease in controllability. Spin stabilisation, where the spacecraft is given a constant angular velocity around one of its principal axes, is often employed as a simple, inexpensive and passive means of attitude stabilisation of these large flexible structures. The benefit of spin stabilisation is that it in addition to providing gyroscopic stiffness to perturbations, aiding the spacecraft in maintaining its desired attitude, it also provides structural stiffness to the flexible sail structures and so reduces the flexing of the sail during slewing. Furthermore slew rates are often constrained in order to avoid exciting structural modes. A method which generates smooth reference motions between arbitrary orientations for a spin-stabilised spacecraft is presented. The method minimises the sum square of the body rates of the spacecraft, therefore ensuring that the generated attitude slews are slow and smooth, while the spin stabilisation provides gyroscopic stiffness to perturbations. In addition, application of Pontryagin's Maximum Principle yields an optimal Hamiltonian which is completely solvable in closed form. The resulting analytical expressions are a function of several free parameters enabling parametric optimisation to be used to provide reference motions which match prescribed boundary conditions on the initial and final configurations. Since parametric optimisation is used rather than numerical optimisation, the method is computationally light and suitable for on-board implementation. The generated reference motions are utilised in the repointing of a spin-stabilised disk solar sail. It is shown that the method is capable of repointing the spin-stabilised spacecraft by utilising the offset between the centre of mass and centre of pressure of the spacecraft to generate the required control torques. In addition the minimisation of the body rates during the motion planning stage results in smooth, slow manoeuvres which have minimal impact on the structure of the spacecraft.