Orbital precession via cyclic pitch for the ultrasail system

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Abstract

UltraSail is a non-traditional approach, utilizing innovative solar sail architecture to achieve sail areas approaching 1 kin-squared. The payload resides in a central bus. Attached to this bus are several "blades" of solar sail film material that are controllable by a tip satellite at the end of each blade. This paper focuses on the dynamics and control of this UltraSail blade/tip satellite system, specifically the precession of each tip satellite/blade system. One of the biggest challenges was to develop an efficient procedure to precess the spin-axis as the UltraSail orbits about the Sun. Two methods were proposed, one using the tip satellite thrusters to precess the spin-axis, and one utilizing the solar pressure force to provide the necessary AV by pitching the blades in a cyclic manner (Cyclic Pitch). These two methods were examined and compared. A model of the blade/tip satellite system was created and simulations were performed and animated in MATLAB™. Cyclically pitching was shown to be a viable method to precess the spin-axis of the blade/tip satellite system, as well as provide considerable fuel savings over using only thrusters.

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Astronomy: precession of earth. The phenomenon we call "precession" was discovered by Greek astronomer Hipparchus when he compared his own circa 200 BC records with older charts. What he saw was that the equinoxes in his day (where the sun's path crosses the celestial equator) were in a different position among the stars than the 150-year-old comparison charts showed. This is due to a gyroscopic wobble of earth's spin axis that takes 26000 years to complete. In this wobble motion, the tilt of the earth stays roughly constant at 23.4 degrees but the orientation is always cha