Solar Sailing with Modulated Radial Thrust

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A study was carried out of the trajectories of space probes powered only by solar sails using modulated radial thrust (MRT). The flux of photons hitting a solar sail exerts a thrust that pushes it away from the Sun, opposing the gravitational attraction. MRT occurs when the sail is always oriented so that this force is directed radially outward and there is a mechanism that allows the effective area of the sail to be varied as the polar angle changes. Four original results are presented. Firstly, for a solar sail subject to MRT, a generalisation of Hamilton's Hodograph Theorem is proved. This theorem provides the basis for sensitive tests of the accuracy of simulation algorithms used in Celestial Mechanics. Secondly, a variety of solar sail orbits are proposed that would allow experimental measurement of the deviations from Newton's Law of Gravitation due to Einstein's Theory of General Relativity. Thirdly, a numerical algorithm is developed that allows a space probe to rendezvous with a number of celestial objects at specified locations and times using only MRT. Fourthly, a novel method of achieving MRT is described and analytical formulas for the resulting trajectories are obtained. Further applications of this work include the development of guidance systems for space probes, the investigation of MRT orbits near artificial libration points, close proximity observations of the Sun that are not confined to the ecliptic, and long-duration exploratory missions to the Kuiper Belt or to the Interstellar Heliopause.

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