Orbit simulation for the ASTROD mission concept

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ASTROD (Astrodynamical Space Test of Relativity using Optical Devices) mission concept is to have two spacecraft in separate solar orbit carrying a payload of a proof mass, two telescopes, two 1-2 W lasers, a clock and a drag-free system, together with a similar L1/L2 spacecraft. The three spacecraft range coherently with one another using lasers to map the solar-system gravity, to test relativistic gravity and to detect gravitational waves. The distances among spacecraft depend critically on solar-system gravity, underlying gravitational theory and incoming gravitational waves, hence a precision determination of the distances as functions of time will determine all these causes. In 2.5 years, the inner spacecraft goes 3 rounds, the outer spacecraft goes 2 rounds, and the Earth 2.5 rounds to the other side of the Sun to conduct Shapiro time delay experiment efficiently. If the mission is extended, around 7.5 years, there is another opportunity. Launch of ASTROD would be after LISA in the Cosmic-Vision Time Frame 2015-2025, we assume an inertial sensor/accelerometer noise requirement of 3×10^{-16} m/s^2(Hz)$^{1/2}$ at frequency f $\sim$ 0.1 mHz, a factor of 10 improvement over LISA. As to the timing accuracy, we assume it is better than 1 ps (300 μm in terms of ranging). The accuracy/stability of clock is required to be 10^{-17} over 1000 s travel time. With these timing and inertial sensor/accelerometer requirements, we simulate the relativistic and solar-system parameter determination; the uncertainties of measuring γ and β is around 1×10^{-9} range, and that of J_2 in the $10^{-10} - 10^{-11}$ range for an 2015 launch choice. We discuss other launch choices and the meaning of this simulation to the test of relativistic gravity and solar-system measurement.