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COMBINED ORBIT DETERMINATION FOR CE-2 AND TOUTATIS BASED ON OPTICAL IMAGING DATA AT FLY-BY

Abstract

Toutatis, international serial number 4179, is a Mars-crosser asteroid with a chaotic orbit produced by a 1:4 resonance with the Earth, and with frequent close approaches to the terrestrial planets, including Earth. Toutatis is listed as a potentially hazardous object by NASA. It flies around the Sun with a semi-major axis of 2.53 AU, and an eccentricity of 0.63, thus completes its orbit around the Sun for every 4.02 annual orbits of the Earth. The dynamical characteristics of Toutatis and its orbital evolution has been an interest for orbital evolution research. China's second lunar probe Chang'E-2, after leaving L2 point, performed a further extended mission starting from April 2012. On December 13rd, 2012, CE-2 was 7,000,000km away from the Earth and flied by Toutatis at a velocity of 10.73km/s. At its fly-by, CE-2 took images of Toutatis using Solar panel monitoring camera for about 25 minutes, which became China's first asteroid fly-by exploration.

This paper conducted a combined orbit determination study for CE-2 and Toutatis using both optical imaging data and historical tracking data. Dynamic equations and measurement equations for both CE-2 and Toutatis are constructed. The relative position relationship between CE-2 and Toutatis at fly-by as well as camera attitude and other parameters is considered in the construction of the joint measurement equation. Practicability of orbit determination for both CE-2 and Toutatis with various orbit determination strategies is tested through covariance analysis. These strategies consider different combinations of the estimation for orbit of CE-2 and Toutatis, solar radiation pressure, camera attitude, and other parameters. The best strategy for combined orbit determination is thus determined. Finally, combined orbit determination for CE-2 with Toutatis is done using all possible data, with orbital accuracy analysis performed afterwards.