SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

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TRAJECTORY ANALYSIS ON ORBITING AND ENCOUNTERING EXPLORATION ABOUT THE MARTIAN MOON (PHOBOS)

Abstract

The exploration for the primary Martian Moon (Phobos) has drawn most attentions from astronomical and astronautical communities, for the potential merit in understanding the Phobos/Deimos' origin and their genetic relation to Mars.

Quite different from the Moon, Phobos has so small mass in relation with its close distance to Mars that orbiting Phobos in a Keplerian-type trajectory in not possible. However, the quasi-periodic trajectories can be constructed in Three Body Problem (i.e., spacecraft, Phobos and Mars), which is referred as Quasi-Synchronous Orbits (QSO) by Russian, and Phobos-Rendezvous Orbits by Japanese.

QSO in Planar Circular Restricted Three Body Problem (PCR3BP) has the Henon's stability, and the C-W (or Hill's) Equation describing the relative motion in formation flying has preferred approximations to QSO. Thus QSO is in essential the perturbed orbit around Mar by Phobos' gravitation. The large relative inclination (up to 0.35 deg) between QSO and Phobos is preferable for the global observation, but it makes QSO unstable or chaotic. Generally the mean altitude is very low (such as 50km) to improve the imager's resolution, which may cause the risk of impacting the Phobos' surface during the mission operation. So it is required that the ability of performing station-keeping to avoid impact caused by chaos motion.

Another way to survey Phobos in close proximity is repeated flybys with Phobos at low distances just as Viking-1 did. For the spacecraft to have a close encounter with Phobos, their orbits must nearly intersect and their passages through the intersection of their orbital planes must occur at nearly the same time. So the spacecraft can be assigned on the Sun-Synchronous Orbit (SSO) around Mars, with its orbital period n:1 (where n is an integer) commensurable with Phobos'.

The trajectory transferring from Earth to Phobos for the orbiting mission is similar with the one for the encountering mission. Both of them may have the identical trajectories during departing from Earth and flying on the heliocentric orbit, and just different in approaching trajectories: the orbiting spacecraft will insert the influencing sphere of Mars along its equator plane, but the encountering spacecraft insert along its meridian plane.